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NEW SERIES. DECADE III. VOL. IV.

No. VIII.—AUGUST, 1887.

ORIGINAL ARTICLES.

I.—On New Species of *Pholidophorus* from the Purbeck Beds of Dorsetshire.

By William Davies, F.G.S.,
of the British Museum (Natural History).

(PLATE X.)

FEW genera of Fossil Fishes contain so large a number of well-defined species as Agassiz's widely-distributed and well-known genus *Pholidophorus*. Above forty species have been more or less fully described by Agassiz and subsequent authors; the geological range extending from the Rhætic to the Purbeck Beds inclusive. The group consists mainly of small or moderate-sized fishes, but few that can be termed large; and with the exception of one species (*P. maximus*),[1] the generic identity of which is doubtful, it contains no fishes of magnitude. Fifteen species have hitherto been recorded as occurring in British rocks by Agassiz[2] and Egerton[3] respectively, the geological distribution being as follows:—Two species from the Rhætic Beds at Aust; nine from the Lower Lias (Lyme Regis; Street; and Barrow-on-Soar); one species from the Inferior Oolite of Blisworth; one from the Great Oolite, Stonesfield; and lastly, two from the Purbeck Beds of Swanage, namely *Pholidophorus ornatus*, Ag., and *P. granulatus*, Egert. These last are fishes of moderate size; with crenulated and otherwise ornamented scales. The fishes which form the subject of this article differ in some important characters from the above-named species; inasmuch that they are diminutive in size, have smooth unornamented scales with entire free margins, another feature being the reduced number of the vertical series covering the flanks. They are apparently rare, the specimens here described being the only examples that have come under my observation. They comprise two forms, one short and deep, the other more elongate.

Pholidophorus purbeckensis, sp. nov. (Plate X. Fig. 2.)

This species is founded upon two specimens, one in the private cabinet of Mr. Damon, of Weymouth, who has kindly submitted it to me for examination, the other on counterpart slabs in the National Collection (B.M. 40635). They are elegant fusiform fishes, less

[1] Agassiz, "Rech. Poiss. Foss." tom. ii. p. 287.
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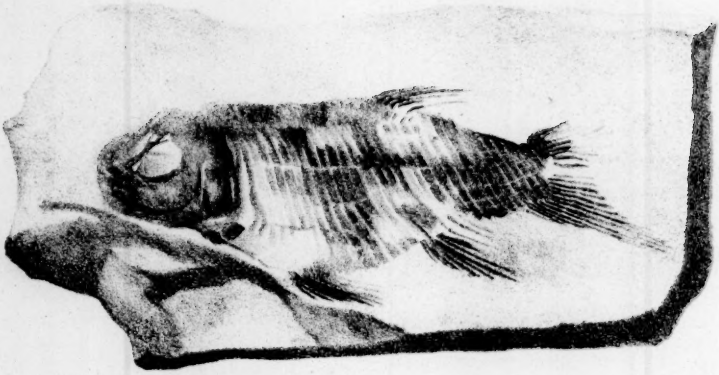

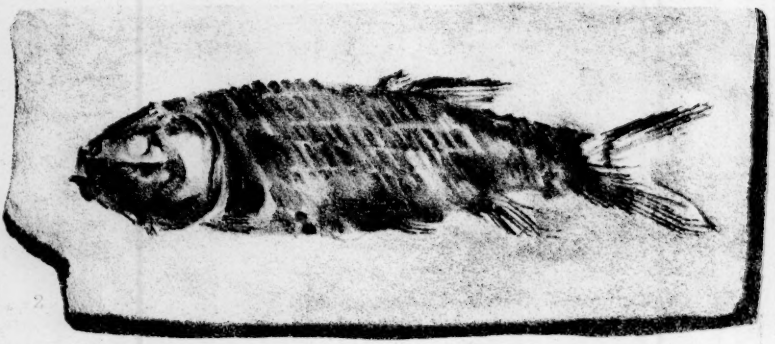

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than 3½ inches (85 mm.) in length. Unfortunately the head in each specimen is so much crushed, that, with the exception of the opercular plates, the component elements are too indistinct for separate description; but its form and relative proportions are fairly well preserved. The orbits are of moderate size; the operculum is oblong, the upper margin being slightly convex, and the sub-operculum is triangular in form. The head forms one-fourth of the entire length of the fish, and is equal to the depth of the body a little in advance of the ventral fins. The scapular arch is nearly concealed by the opercular plates. The paired fins are imperfect, a few rays of each only being preserved, which suffice to indicate their position. The ventrals are placed midway between the attachment of the pectorals and the anterior ray of the anal fin. The latter fin is also imperfect, insomuch that the distal bifurcated extremities of the rays are wanting. It consists of ten strong and unarticulated rays, and is 9 mm. in length; no fulcral scales are preserved on either specimen. The dorsal fin rises from the middle of the back and opposite the interspace dividing the anal and ventral fins. It is short but incomplete, the few rays preserved are moderately thick, the anterior ray being strengthened by several imbricating and elongate fulcra. The caudal fin is deeply cleft and equilobed, like the tail of the contemporary *P. ornatus*. There are sixteen articulated rays, eight in each lobe, preceded by acutely pointed fulcral scales, those on the upper lobe being the largest. The scales on the Museum specimen are all more or less broken, but the characteristic or principal series covering the flanks are well preserved on Mr. Damon's specimen.[1] These form four rows of high and narrow scales which gradually diminish in height as they approach the tail, and are completed by smaller scales above and below. The upper or dorsal row of large scales are slightly curved, the anterior series of the other rows are nearly rectilinear in form. Those of the second, or lateral line series of scales are the largest, being four times as high as they are broad, whilst in the next series these proportions are as three to one. There are from 32 to 34 scales in each longitudinal row. The lateral line is prominent and continuous, with a slight curve, from the operculum to the caudal fin. The side scales show the peg and notch articulation, and are strengthened on the inner surface by the continuation of the peg as a mesial vertical ridge to the articulating depression on the lower margin of the scale. The scales are coated with shiny ganoine, upon which may be seen with a lens a few striæ, or lines of growth, and, compared with most species of *Pholidophorus*, the scales are relatively thin, hence their imperfect preservation. The specimens are from the Lower Purbeck Beds of the Isle of Portland.

PHOLIDOPHORUS BREVIS, sp. nov. (Plate X. Fig. 1.)

The little fish I have thus designated is in the National Collection (P. 1074), and is readily distinguished from the preceding species

[1] See Plate X. Fig. 3. The entire fish has been drawn (but not yet published), for a new edition of the Supplement to the Geology of Weymouth and the Isle of Portland.

by its shorter and deeper body. In shape and relative proportion it resembles *P. granulatus*, and might be taken for its young form: but the unornamented scales with entire margins preclude its being referred to that species. The extreme length is 77 mm. (3 inches) of which the head occupies the fourth part; between the hinder margin of the operculum and the insertion of the caudal fin the body measures 40 mm., and the depth in front of the ventral fins is 25 mm. The head is crushed, and but little of the external surfaces of the bones are preserved. The orbits are not large, nor are any teeth visible. There is not the slightest evidence by depression or otherwise of the presence of the notochord. The fins appear to have been small and the rays few. The insertion of the dorsal fin is a little in advance of the opposite anal fin. Long acute imbricating scales cover the front ray of both fins. The caudal fin is composed of about 20 strong and jointed rays with several fulcral scales above and below, and is not deeply cleft. The structure and general form of the scales are the same as in *P. purbeckensis*; namely, high and narrow scales on the flanks, which gradually decrease posteriorly, with small scales on the dorsal and abdominal regions. Most of the larger scales are either wanting or broken: but well-marked impressions of the outer surfaces of those missing are preserved on the matrix. On another fragment of a larger individual (B. M. P 3607), the scales are in better position, and also show the inner side. Both specimens are from the Upper Purbeck Beds at Upway, near Weymouth; and formed part of the Egerton and Enniskillen collections respectively.

It is deserving of remark that *Pholidophorus* is found associated with *Lepidotus* in many of the marine formations of the Jurassic period, and also in the estuarine deposits of the Purbecks, proving that species of both genera frequented estuarine waters.

DESCRIPTION OF PLATE X.

Fig. 1. *Pholidophorus brevis*. British Museum (P 1074).
,, 2. *Pholidophorus purbeckensis*, drawn from the two slabs in the British Museum (40635).
,, 3. ,, ,, enlarged external view of the flank scales on Mr. Damon's specimen.
,, 4. ,, ,, restored inner view of the same scales showing the medial ridge.

II.—On the Occurrence of a New Fossiliferous Horizon in the Ordovician Series of the Lake-District.

By H. Alleyne Nicholson, M.D., D.Sc., F.G.S., and John E. Marr, M.A., F.G.S.

BELOW the "Coniston Limestone Series"—if we include under this general title not only the Coniston Limestone proper, but also the "Style End Grassing Beds" of Long Sleddale and the "Dufton Shales" of the Cross Fell area—no fossiliferous beds have hitherto been detected in the Lake-district till the horizon of the Upper Skiddaw Slates (Llanvirn Series) is reached. Between these two horizons are placed the thick and varied volcanic rocks which

have usually been grouped together under the name of the "Borrowdale Series" (the "Green Slates and Porphyries" of Prof. Sedgwick); though it may be taken as certain that this name covers more than one series of volcanic ejecta. Up to the present time, no strata containing fossils have been detected in connection with any of the rocks which have been included under the general title of the "Borrowdale Series." The object of the present communication, however, is to draw attention to a group of fossiliferous shales which we have found to be associated with certain of these volcanic rocks.

The shales in question occur on the north side of the great mass of the Skiddaw Slates of the Lake-district, in what has been spoken of as the "Caldbeck Fells Area"; and their general position will be made clear by the accompanying sketch-map.

Sketch-map of Carrock Pike and the district immediately round it, on the scale of one inch to a mile. (The boundaries of the intrusive igneous rocks are in part taken from Mr. Clifton Ward.) *S.* Skiddaw Slates, for the most part highly metamorphosed; *d.* Drygill Shales; *e.* Lavas and ashes ("Eycott Series"); *c.* Carboniferous rocks; *g.* Granite. *G.* Gabbro (the "hypersthenite" of Mr. Ward); *D.* Intrusive diorite (?); *F.* Sphærulitic felsite.

The main area of the Skiddaw Slates in the Lake-district, as is well known, is followed to the south by the main area of the so-

called Borrowdale rocks, while it is flanked on the north and north-east by a narrow strip of volcanic rocks which runs from Eycott Hill near Troutbeck Station, through the range of the Caldbeck Fells, to Binsey Crag and Torpenhow Common. The upward sequence of the volcanic rocks of the Caldbeck Fells is concealed from view by the overlapping Carboniferous Limestone. On the other hand, the relations which these rocks bear to the Skiddaw Slates to the south of them have not hitherto been precisely ascertained, partly from an insufficiency of sections, and partly owing to the intercalation between the two series at the eastern end of the range of the great intrusive igneous masses of Carrock Pike and Great Lingy.

The strata to which we wish to direct attention here are situated immediately to the north of the intrusive masses just spoken of, and are, therefore, of special interest as lying between the Skiddaw Slates on the one hand and the volcanic rocks of the Caldbeck Fells on the other hand; though it cannot be said that their stratigraphical relations with either of these are absolutely clear. They occupy the summit of the valley between High Pike and Carrock Pike, and are fully exposed in the course of Drygill Beck, the head tributary of Carrock Beck. We shall, therefore, speak of them as the "Drygill Shales." The following is the section seen in Drygill in descending the stream. The ridge from which Drygill Beck flows north-eastwards is probably composed of intrusive igneous rocks, but the summit of the ridge is covered with peat, and no rock is seen in place. The first rocks seen in the highest part of Drygill are pale drab-coloured shales, which dip at tolerably high angles to the S.S.W. and strike W.S.W. and E.N.E. No fossils were detected in these beds; but a more prolonged search would probably bring organic remains to light. These are succeeded below by blue-grey shales, weathering white, and similarly coloured mudstones, with iron-stained joints, containing ill-preserved Brachiopods and other fossils. These beds are best seen in Drygill itself, but are also exhibited in the western fork of the stream.

The beds just spoken of abut against a mass of intrusive igneous rock, which occupies both sides of the stream for some little distance below the point where the eastern and western forks unite. This rock decomposes by exposure to the weather to a soft brownish-green ashy-looking rock, but it seems really to be very similar to the intrusive mass which occurs in Brandy Gill, and which Ward has spoken of as a "diorite." Very probably the mass in Drygill is only an offshoot from this.

Below the preceding, the stream cuts through a series of dark blue-grey or nearly black mudstones, crowded with fossils, which are fairly preserved, though slightly distorted by cleavage. The general strike of the beds here varies from S.W. to W.S.W., the dip still being southerly; and the whole series is much broken and intersected by mineral veins. These beds rest upon a series, of no great thickness, of remarkable contemporaneous volcanic rocks in the form of breccias with associated bands of quartz-felsite, which are unlike the ordinary lavas and ashes of the Lake-district in their

nearly white colour.[1] Lastly, these volcanic beds are underlaid by a final mass of dark fossiliferous mudstones, full of Brachiopods and Trilobites.

The following is a list of the fossils which we have obtained from the Drygill Shales :—

Ampyx rostratus, Sars.	*Beyrichia complicata*, Salt.
Calymene cambrensis, Salt.	*Leptæna sericea*, Sow.
Lichas laciniatus, Wahl. ?	*Obolella ?*
Stygina Murchisoniæ, Murch.	*Orthis testudinaria*, Dalm. (abundant).
Trinucleus favus, Salt. ?	

The strata above described are not exposed elsewhere in the Caldbeck Fells, to our knowledge, nor are we acquainted with any rocks in the Lake-district which can be precisely paralleled with them. Moreover, the relations of the strata of this small, disturbed, and shattered area to the rocks in the immediate neighbourhood are not at all clear. Their northern boundary is probably a faulted one, since the whole series is dipping in a southerly direction, whereas the general dip of the volcanic rocks of the Caldbeck Fells is northerly. No actual junction, however, is seen between the lowest mass of the Drygill Shales and the volcanic rocks in question. Below the lowest exposure of Drygill Shales is an interval of barren ground, followed by an exposure of a hard grey lava. Then there is a long interval in which no rock at all is exposed to view, and, finally, the lower part of Carrock Beck is excavated in a series of lavas which may be regarded as a direct continuation of those of Eycott Hill, with which they agree in all essential particulars.

The relations of the Drygill Shales to the south are still more obscure, since no rocks of any kind are exposed between the head of Drygill Beck and the head of Brandy Gill (see sketch-map). Here we meet with a mass of an imperfect granite, with the general aspect of a felsite. Following the stream downwards, this is seen to be succeeded by a mass of intrusive igneous rock, which Mr. Clifton Ward identified with some doubt as a diorite (Quart. Journ. Geol. Soc. vol. xxxii. p. 16). Southwards of this, again, is the westward continuation of the gabbro ("hypersthenite" of Ward) of Mosedale Crags. This, finally, is succeeded to the south by the highly-altered Skiddaw Slates which occupy this portion of the valley of the Caldew, and which appear to be cut off from the igneous rocks on the north by a great fault.

The stratigraphical relations of the Drygill Shales are, thus, obscure. So far as we are aware, the only published notice of these beds is the incidental mention of them by the late Mr. Clifton Ward in his memoir on "The Granitic, Granitoid, and Associated Metamorphic Rocks of the Lake District" (Quart. Journ. Geol. Soc. vol.

[1] From a remark made by Mr. Ward (Quart. Journ. Geol. Soc. vol. xxxii. p. 24), we should be disposed to infer that this observer regarded the peculiar characters of these beds as due to extreme weathering. Mr. Teall has been good enough to examine for us a specimen of one of the felsitic bands associated with these light-coloured breccias, and informs us that it exhibits porphyritic quartz and felspar in a cryptocrystalline ground-mass. Assuming it to be a lava, he would consider it to be a slightly altered liparite.

xxxii. pp. 17 and 24). This gifted observer considered the Drygill Beds as being referable to the Skiddaw Slates. He was, in fact, of opinion that we had here an instance of a passage between the Skiddaw Slates and the Volcanic Series, by the intercalation of the highest portion of the former with the base of the latter in alternating succession—a phenomenon of which he believed he had found instances in other localities in the Lake-district. It is certain, however, that, as regards the rocks here in question, this conclusion could not have been arrived at by a geologist of such experience except under the influence of a preconceived theory. Lithologically, the Drygill Shales do not at all resemble any members of the Skiddaw Series, and they do not precisely resemble any rocks which are known to us as occurring in the Lake-district. They are of the nature of mudstones, with a rough cleavage; and of all the Ordovician rocks of the North of England, it is, perhaps, the "Dufton Shales" which they most nearly resemble. Some of the beds are also very like parts of the "Skelgill Series." Apart, however, from the comparatively unimportant character of their lithological nature, the Drygill Shales swarm with fossils—of few *species* certainly, but of great abundance as *individuals*—which leave no doubt at all as to their *general* position in the Ordovician Series. The presence in abundance of such fossils as *Orthis testudinaria*, Dalm., *Leptæna sericea*, Sow., and *Calymene cambrensis*, Salt., *Ampyx rostratus*, Sars., and *Stygina Murchisoniæ*, Murch., renders it certain that the Drygill Shales are of Llandeilo-Bala age. Upon the whole, the general characters of the fossils would lead us to refer the Drygill Shales to about the horizon of the Llandeilo Limestone, or to a slightly higher point in the series.

As regards the Lake-district succession, the palæontological evidence renders it absolutely certain that the Drygill Shales are younger than the Upper Skiddaw Slates and older than the Coniston Limestone proper. They agree most nearly with the "Dufton Shales" as regards their fauna, but they differ from these in the predominance of *Orthides* of the type of *O. testudinaria*, Dalm., and in various other points. On the other hand, it is not at present possible to decide positively as to the relations which the Drygill Shales bear to the Volcanic Series. From their general position between the Skiddaw Slates on the one hand and the lavas and ashes ("Eycott Series") of the Caldbeck Fells on the other hand, we should be led to conclude that they occupy a place low down in the latter series. It is quite certain that they do not belong to any part of the Skiddaw Series; and there is, in fact, no evidence that the series of the *Upper* Skiddaw Slates is present at all in this particular area. On the contrary, the Skiddaw Slates of the Caldew Valley appear to be faulted down against the igneous rocks to the north of them, and it is probable that the Upper Skiddaws are thus completely cut out. Again, the Drygill Shales are lithologically and palæontologically distinct from any of the fossiliferous rocks which can clearly be shown to lie *above* the Volcanic Series. It would thus seem almost certain that, though their present position

is probably largely affected by faulting, they must be referred to the Volcanic Series itself.

In corroboration of our view that the Drygill Shales form part of the Volcanic Series, we may draw attention for a moment to the unequivocal occurrence of bands of mudstone—unfortunately apparently not fossiliferous—in the lavas and ashes of this series in another locality. The locality alluded to is Falcon Crag, near Keswick, selected by Mr. Ward as affording a typical section of the Volcanic Series (Geology of the English Lake-district, p. 13), though he does not mention the particular feature here in question. Above the lowest lava in this section, as seen in Cat Gill, we find a series of unaltered ashes and breccias, sometimes fine, sometimes of coarser grain, which alternate with thin bands of grey shaly mudstone. These alternating beds are sometimes so mixed and blended together at their lines of junction, that it is clear that the ashes were from time to time abundantly showered into the sea in which the grey mud of the shales was in course of deposition. The mudstones have no resemblance lithologically to the Skiddaw Slates, and they are so much squeezed and jointed that all attempts to detect fossils in them have hitherto proved abortive. They are, however, full of ferruginous stains and cavities which may possibly represent organic remains now destroyed. We have here, then, an unquestionable instance of the occurrence of contemporaneous mudstones among the lavas and ashes of the Volcanic Series; and this would so far support our reference of the Drygill Shales to the same series. At the same time, it should be added that we are not disposed to regard the mudstones of Falcon Crag as being the precise equivalent of the Drygill Shales. On the contrary, the latter not only have a vastly greater thickness, but are associated with a peculiar type of volcanic ejecta, of which we find no representative in the section at Falcon Crag.

III.—On Some Changes of Level during the Glacial Period and their Supposed Cause.

By T. F. Jamieson, F.G.S., Ellon, Aberdeenshire.

At the close of the Glacial Period in North America the basin of the Red River was occupied by a large lake which has received the name of Lake Agassiz. It extended from what is now Lake Winnipeg southward for some hundreds of miles to the watershed of the Minnesota River. The bottom of this old lake now forms an extensive level plain famous for its fertility and the fine crops of wheat it produces.

At present the drainage of the Red River Valley flows northward into Lake Winnipeg and from thence along the Nelson River into Hudson's Bay; but during the existence of the lake in question this outlet is supposed to have been blocked by the great glacier which formerly covered all the region to the north, and which was then slowly retreating owing to the advent of a milder climate. As the drainage of the glacier went into the lake, there must have been an ample supply of water to keep it constantly brimming. The

quantity of water it discharged, and the length of time the lake existed, is further shown by the size of the channel which the river flowing out of it has cut through the thick bed of drift to the southward. This channel forms a long trough, from 100 to 225 feet in depth, commencing at Lake Traverse and extending for about 250 miles along the course of the Minnesota River to its junction with the Mississippi. The fact of the excavation of this remarkable trough being due to the outflow of the lake which formerly filled the basin of the Red River was pointed out by Gen. G. K. Warren in 1868.

The beaches left along the margin of the vanished lake are still quite distinct, and have lately been made the subject of careful examination by Mr. Warren Upham, of the U. S. Geological Survey.[1] He has executed a series of levellings along the uppermost beach for a distance of 142 miles, extending from its outlet at Lake Traverse northward to Maple Lake, which is about 20 miles east of Crookston, and one interesting result of his work is to show that the beach does not form a horizontal line, but slopes gradually upwards from south to north along the whole distance he carried his levels. Its height at the south end is about 85 feet above the present level of Lake Traverse, or 1055 feet above the sea; while at Maple Lake, where the levelling stopped, it is 1180 feet above the sea, showing a gradual rise of 125 feet in the course of 142 miles. "Through this distance," says Mr. Upham, "the upper beach clearly marks one continuous shore-line, and the accuracy of our levelling is attested by close agreement with railroad surveys at five widely-separated points."

The ascent of this beach from Lake Traverse northward is at the rate of about $\frac{4}{10}$ of a foot per mile for the first 60 miles. Further north, through the next 80 miles, its rate of ascent is somewhat greater, varying from three-fourths of a foot to $1\frac{1}{2}$ foot per mile. The portion of the upper beach thus examined extends through a prairie region very favourable for exploration and levelling. Further on it turns to the E. and N. through a trackless forest with impassable swamps, where it would be difficult to trace its course.

There are two other beaches, at lower levels, left by the lake as it gradually subsided, owing to the wearing down of its outlet. These also have been examined by Mr. Upham with somewhat similar results. Both are found to have a gradual upward slope to the north, as compared with the surface which a sheet of water would now have if confined in this valley. The second beach, in the space of 150 miles, rises about 70 feet with a nearly uniform slope of a little less than half a foot per mile. While the third or lowermost beach was found in the course of 135 miles to rise northward to the extent of 50 feet, and at a later period of the lake's existence to half that amount.

Assuming these levellings to be correct, and assuming also that each of the supposed beaches does actually represent one of the old

[1] W. Upham, Lake Agassiz, Bulletin of the Minnesota Acad. of Nat. Science, vol. ii. p. 290, 1882.

water-lines at which the surface of the lake formerly stood, we have here a very interesting question presented to us. How is it that these old beaches are not now horizontal, but rise gradually as we follow them to the north? Has the ground risen to the northward since the lake disappeared, or did the surface of the lake form a plane which was not horizontal, while the land remained all along stationary as it is? The latter is the explanation Mr. Upham adopts.

According to the law of gravitation, matter of all kinds exerts an attractive force in proportion to its mass, and varying inversely as the square of its distance from the body it attracts. Mr. Upham, therefore, supposes that the glacier, by virtue of this attractive force, drew the water towards it, so that the lake rose to a higher level near the glacier than it did farther off. The northern barrier of the lake, he says,[1] "was the receding Continental glacier. All the differences of the once (?) level lines of Lake Agassiz from our present level-line would be produced by the gravitation of the water of the lake towards this ice-sheet. At first this attraction had a large effect upon the lake-level, because of the nearness of a great depth of ice on the east in Northern Minnesota, and northward in British America; but it was gradually diminished to a comparatively small influence when these ice-masses had been melted and the attracting force proceeded from the region far north between Lake Winnipeg and Hudson Bay."

Whether we can agree with Mr. Upham in this explanation or not, we are certainly much indebted to him for the discovery of a very remarkable and interesting fact. Another explanation, however, may be offered.

If, as some geologists believe,[2] the outer crust of the earth reposes at no great depth upon a stratum of mineral matter in a state of fusion, we may without violence suppose that the addition of a heavy load upon the surface would cause the crust to press deeper down into this soft stratum and drive part of it away to where the pressure was less. Then, if the load was afterwards removed, and the pressure on the surface thereby relieved, the subterranean fluid or semifluid matter would tend to return towards the place it formerly occupied, until an equilibrium of pressure was restored, thus causing the surface of the depressed tract to rise again. In accordance, therefore, with this notion we may conceive that the weight of the great glacier had caused a depression of the northern region on which it lay, and that afterwards, when the ice melted, the land, being relieved from its load, gradually rose again, so that the old beach, which was formerly horizontal, now presents an upward slope to the north, such as Mr. Upham has found.[3]

Both explanations would account for the facts. In either case the result would be that the old shore of the lake would now rise towards the place where the glacier formerly existed. To the one theory it may be objected that it overestimates the attractive force of

[1] *loc. cit.* p. 313.
[2] See O. Fisher, Physics of the Earth's Crust, p. 223, and elsewhere.
[3] See T. F. Jamieson, GEOL. MAG. Sept. 1882.

the ice, to the other that it overestimates the flexibility of the earth's crust. Here both causes operate to produce the same result; but if we could find a case where we could test the two under conditions where the results would be different or opposite, then it might be seen which would prevail.

Such a case would seem to be found in another great lake called Lake Bonneville, which formerly existed in the salt desert of Utah during the Quaternary period. This lake arose from a change in the climatic conditions of that region. Now it is so dry that the water has evaporated from the greater part of the basin, leaving it a salt desert; but formerly the precipitation of moisture was so much greater that the basin was filled by a body of water as large as Lake Huron, and nearly 1000 feet deep. Here, then, we have a tract of ground which formerly sustained the pressure of a heavy load of water that has now disappeared. If the surface of Lake Bonneville was influenced by the attraction of surrounding masses, its waters should have stood highest at their margin, where they adjoined the mountain ranges which encompassed them, and its shore-lines (which are still remarkably distinct) ought to find their greatest altitude in such places. On the other hand, if the land rose in any degree when the load of water was taken off it, the old beaches should now be highest towards the centre of the basin where the water was deepest and the load heaviest. Whereas, at the outer rim of the lake, where the water was shallow, no material rise might be expected. This, I think, is a fair inference in regard to both theories. Now, what do we find?

According to Mr. G. K. Gilbert,[1] who has devoted much time and labour to the exploration of the locality, the answer would seem to be decidedly in favour of the latter supposition. There were numerous islands in this old lake, and its shore-line encircles them so distinctly that its level can be ascertained not only round the margin, but also in the midst of the basin. This shore-line is not now level, but rises higher in some parts than in others. A map of the lake was made, its shore-lines carefully traced, and the altitudes marked upon the map. The final result of the whole survey went to show that the highest parts of the beach lie within the area of the main body of the lake, while the lowest ones are at the extreme north and south ends, and the general expression of the deformation of the surface indicated a low broad dome of elevation to have taken place, having its crest situated over the centre of the main body of the lake. The difference of level between the margin of the main body of the lake and its centre is not less than 100 feet, but including observations on outlying bays it amounts to 168 feet. Gilbert, therefore, believes that the bottom of the lake has risen since the water disappeared, and he seems to think it probable that the cause of this is to be found in the removal of the load of water that formerly lay upon it. He discusses two other theories, but finds them both inadequate to account for the facts.

[1] G. K. Gilbert, "On the Inculcation of Scientific Method by Example," Amer. Journ. of Science, vol. 31, April, 1886.

I am far, however, from wishing to lay too much stress on this case of Lake Bonneville. Its outline is intricate and extensive, and it may be that a more exhaustive survey would modify the results arrived at by Mr. Gilbert. It is quite possible also, as he himself remarks, that the deformation of the old shores may be due to subterranean movements proceeding from an entirely different cause. But, so far as the Survey has gone, it certainly fails to show that there was any notable gravitation of the lake-waters towards the high mountains on the East, such as might have been expected upon the hypothesis that a strong attractive force was exerted by these mountain-masses.

Assuming, for the present, that the bottom of the lake has actually risen 168 feet in consequence of being relieved from the pressure of 1000 feet deep of water, we may use this result to ascertain what might be the effect produced by the disappearance of a like depth of ice. Taking the specific gravity of glacier-ice at 875 as compared with water at 1000, the result would be a rise of 147 feet—or say in round numbers 150 feet for a thousand feet of ice. This would agree tolerably well with some of the changes of level that have been observed in regions formerly occupied by large glaciers.

IV.—On a Method of Determining a Lower Limit to the Age of the Stratified Rocks.

By Charles Davison, M.A.,
Mathematical Master at King Edward's High School, Birmingham.

1. THE following is an attempt to determine a lower limit to the time required for the accumulation of the stratified rocks. It is not supposed to be an accurate estimate, for the data on which it is based are confessedly imperfect; but it is thought that the method employed may be of some little use when more exact determinations can be made of the physical constants involved.

The first part of the method is founded upon the observed fact that most, if not all, of the stratified rocks, throughout the period of their formation were deposited in shallow water; the latter part on the law of secular cooling deduced by Sir W. Thomson for the case of a solid earth, though not on the value of the initial temperature used by him. As a consequence of secular cooling the outer parts of the earth's crust are folded by lateral pressure, the rocks above the troughs gradually subsiding as the troughs of the folds deepen, by reason of the weight of the rocks, and of the sediment, if any, deposited above them.

2. The fact that stratified rocks are chiefly shallow-water deposits indicates that the rate of sedimentation is generally, and on the whole has been, greater than the rate of subsidence.[1] Now, the sediment brought down by a river is used: first, for keeping the level of the delta-surface close to the level of the sea; secondly, for extending the delta laterally by means of the surplus sediment.

[1] The rate of subsidence at any time is here measured with respect to the level of the sea at that time.

Let V be the number of cubic feet of sediment brought down by a river every year, and A the area of its delta in square feet. If the whole of the sediment were spread over the present delta, so as to keep its surface close to the surface of the sea without enlarging the area of the delta, the average rate of subsidence would be $V \div A$ feet per year. If, however, as is generally the case, the sediment is spread over a larger area, increasing the delta laterally, then the average rate of subsidence must be less than $V \div A$ feet per year. Thus, *the volume of sediment brought down by a river in a year, divided by the area of the delta, gives a superior limit to the average rate of annual subsidence in the region of the delta.*

As the area of the delta increases, this limit decreases, continually approaching the true mean rate of subsidence. The true mean rate would also of course be known, if we could ascertain the amount of surplus sediment used for increasing the area of the delta, and therefore the amount left for keeping the delta-surface in shallow water.

It should be noticed that the mean rate of subsidence is independent of the recurrence of glacial periods and of all changes that may take place in the intensity of the denuding forces. True, in estimating its superior limit, we have left out of account the materials derived from littoral erosion and from some volcanic eruptions that may be swept by currents into the delta-area; but we cannot err greatly in neglecting them.

As an example, let us take the case of the Mississippi. Dr. A. Geikie states that the area of its delta is 12,300 square miles, or 342,204,320,000 square feet; and that the volume of sediment brought down by the river every year is 7,459,267,200 cubic feet.[1] Hence, the average rate of subsidence throughout the area of the delta cannot be greater than $\frac{1}{46}$ of a foot per year, or, more exactly, 2·18 feet per century.

Now, the mean rate of subsidence is not uniform throughout the whole period of formation of a fold, for it is evidently zero at the very commencement and also at the epoch when subsidence changes to elevation, and there may be pauses in the process. But, in different parts of the earth, there must be folds in different stages of formation; and the average of the mean rates of subsidence of all known areas of sedimentation will give the true mean rate of subsidence for the present time. Not having the necessary data, however, for river-deltas other than that of the Mississippi, we may assume the highest value of the mean rate of subsidence at the present time to be $\frac{1}{46}$ of a foot per year, which, it is worth noticing, is of the same order of magnitude as the estimated rate of elevation of the north coast of Scandinavia.

3. The mean rate of subsidence over the whole earth has not, however, been uniform throughout geological time; and it remains for us to determine, as nearly as we can, the law according to which it changes. This, I believe, it is possible to do, if we accept the hypothesis of a solid globe cooling from a high initial temperature. In a paper lately read before the Royal Society, I have shown that

[1] Text-book of Geology, pp. 389, 444.

the following laws are very nearly true, and that they do not depend on the initial temperature of the earth (except in so far as the rate of conductivity of rock may vary with the temperature) :—

(*a.*) Folding by lateral pressure takes place only to a limited depth from the earth's surface, below this depth giving place to stretching by lateral tension; and the depth at which folding changes to stretching varies directly as the square root of the time since consolidation. Also, the rate at which the unstrained surface recedes from the surface of the earth varies inversely as the square root of the same time.

(*b.*) The total amount of rock folded in any given interval also varies inversely as the square root of the time since consolidation.[1]

On both accounts, then, it would seem probable, though not, it should be remembered, actually proved, that the mean rate of subsidence, due to folding by lateral pressure, should vary according to the same law.

Assuming this to be the case, let the total amount of subsidence in t years be x feet, so that $\frac{dx}{dt}$ measures the rate of subsidence at the time t. Also, let a feet be the average thickness of the stratified rocks deposited throughout geological time, and T years the time required for its deposition.

Then, $\frac{dx}{dt} = \frac{\lambda}{\sqrt{t}}$, where λ is a constant; and $x = 2\lambda\sqrt{t}$, no constant of integration being required, for x and t vanish together.

But, when $t = T$, we have $x = a$, and $\frac{dx}{dt} = \frac{1}{46}$, taking the mean rate of subsidence at its highest value;

so that $\lambda = \frac{\sqrt{T}}{46}$;

$$\therefore \quad x = \frac{\sqrt{Tt}}{23}, \text{ and } a = \frac{T}{23},$$

$$\therefore \quad T = 23\ a.$$

If we knew the average thickness of the sediment deposited throughout the whole of geological time, the value of T obtained from the last equation would give a lower limit to the length of time required for the formation of the stratified rocks; but unfortunately, the necessary data are not to be had. The maximum thickness of the sedimentary rocks has, however, been estimated by Dr. S. Haughton and Prof. E. Hull, at 177,200 feet; and I cannot think we shall be far wrong if we take this as the average thickness

[1] "On the Distribution of Strain in the Earth's Crust, resulting from Secular Cooling; with special reference to the Growth of Continents and the Formation of Mountain Chains," read May 5, 1887.

of the sediment deposited within the limited delta-areas,[1] remembering:—(1), that all stratified rocks are largely formed from the denudation of those previously existing, and (2), that there may have been intervals between successive geological periods represented by formations now unknown to us or not included in the above estimate.

Putting, then, $a = 177{,}200$ feet in the last equation, we find

$$T = 23 \times 177{,}200 = 4{,}075{,}600 \text{ years},$$

i.e. just half what it would have been had the rate of subsidence been uniform and equal to the rate at the present time.

But, if we may have over-estimated the average thickness of the stratified rocks, we have, on the other hand, taken a superior limit to the rate of subsidence. Also, in the above calculation, it was supposed that sedimentation, like subsidence, began as soon as the earth solidified; whereas, it is possible that a considerable interval elapsed, thereby postponing the formation of the stratified rocks to a time when the rate of subsidence was slower than at first.

We may conclude, therefore, on both accounts, that for the formation of the sedimentary rocks a time is required of *not less than four million years*, and possibly of a period very much longer than this.

V.—On Parallel Structure in Rocks as indicating a Sedimentary Origin.

By Ch. Callaway, D.Sc., M.A., F.G.S.

IGNEOUS rocks and crystalline schists are often associated with each other in such a manner as to compel the conclusion that either the igneous rocks have been formed out of the schists or the schists out of the igneous rocks. There are other cases in which the two kinds of rock are less intimately related; parallel structure is wanting, the junctions are sharply defined, and there is no evidence of an original mineral gradation. These are examples of the ordinary irregular intrusion of igneous rocks in schists. But there is a third group in which the characters are intermediate. In these rocks, structural parallelism is more or less distinct, and there is often a partial blending of the two kinds of rock at the line of contact; but other indications forbid the belief that the schists have been elaborated out of the associated igneous masses. The question then arises: Are we here dealing with cases of intrusion, or are we driven to conclude that the igneous rocks have resulted from the fusion of schists? The answer to this question has obviously an important bearing upon the genesis of the crystalline schists.

The conversion of schists into granite and the like is maintained by the officers of the Geological Survey of Ireland,[2] and I have dealt with their evidence in a paper published in the Journal of the

[1] Dr. Croll has very clearly shown that there may be a considerable difference between the maximum and average thicknesses of a formation; but it will be remembered that he calculated the average over a belt 100 miles broad round the whole coast-line.—Geol. Mag. 1871, Vol. VIII. p. 101.

[2] Survey Memoirs, Nos. 93, 94, 95, 104, 105, 113, 114, *passim*.

Geological Society,[1] and in a second communication read before th Society on the 6th of April last. My contention is that in the dis tricts examined there is no gradation whatever between schist an granite; but that, on the other hand, the igneous rocks frequentl acquire a foliated structure. My chief object in writing, howeve is to call attention to a series of articles by Prof. J. D. Dana, whic appeared in this MAGAZINE[2] in 1881. These papers deserve specia notice, not only for the interest of the facts described, but becaus they present the case for the sedimentary origin of igneous rock with exceptional force.

Prof. Dana's theory is expressed in the title of his memoir:— "On a Case in which various massive Crystalline Rocks includin Soda-Granite, Quartz-Diorite, Norite, Hornblendite, Pyroxenite, an different Chrysolitic Rocks, were made through Metamorphi Agencies in one Metamorphic Process." The district described i in the township of Cortland, to the north of New York City, an lies on both sides of the River Hudson. Associated with the above named plutonic rocks are gneiss, mica-schist, and limestone. Minut details of the various rocks are unnecessary for my present purpose

The argument of Prof. Dana is arranged under the followin heads:—

"1. *Evidences of more or less Complete Fusion.*"—The evidence i this section simply goes to prove that the *igneous* rocks have crystal lized from a state of fusion. So far from affirming a passage betwee these and the schists, the author states that at Cruger's Point, at a junction between schist and soda-granite, the former "bears evidence of partial fusion and exhibits other contact-phenomena." If there are "contact-phenomena," there cannot be a gradual transition.

"2. *Evidences as to Condition of Fusion.*"—Were these rocks fused *in situ*, or were they erupted from below? Prof. Dana considers that in the former case the results of fusion "are likely to vary at comparatively short intervals, because sedimentary beds often vary thus." "Sediments . . . are liable to frequent and sudden changes as to material, which igneous outflows cannot imitate." Here I must distinctly join issue with Prof. Dana. Some of the banded gneisses of the Malvern Hills show alternations of different kinds of mineral matter as "frequent and sudden" as of any sedimentary strata in the world. Thin red seams in a black groundmass form a banding as clear and vivid as the stripes in the American flag. But the seams are granite and the groundmass is diorite, and the rock with this parallel banding passes, sometimes abruptly, into ordinary diorite with irregular veins of granite. In illustration of the singular way in which igneous rocks mimic sedimentaries, I may refer to the so-called "conglomerates"[3] in the crystalline region west of Galway. Granite veins, intruded into jointed diorites, have lapped round and enclosed joint-blocks in such numbers as to suggest the inclusion of pebbles in sediment. Where the rocks have

[1] May, 1885, p. 221.
[2] Feb. p. 59; March, p. 110; April, p. 162.
[3] Described in my paper read before the Geological Society on April 6th.

been exposed to regional pressure, there is produced a rough parallelism amongst the fragments, and this enhances the sedimentary appearance.

"3. *Special Facts from the Cortland Region.*"—I shall confine myself to the essential points, omitting those which, though not irrelevant, would count for little if my main contentions are sustained.

Some interesting contact-phenomena are seen near Cruger's Point (p. 114). The mica-schist towards the north comes to an end against soda-granite and quartz-diorite. Approaching the igneous rocks, the schist "becomes increasingly staurolitic and garnetiferous, and passes in places into a true gneiss." *Pari passu* with this mineral change, the schist becomes more and more contorted, and is "interlaminated with nodose-lines of quartz, vein-like in origin." At the junction, "the schist is mostly a garnet rock containing much fibrolite and staurolite, and the latter is in some places granular-massive in a small way. Just below the granite, the layers are a compact body of flexures, and *in the soda-granite*[1] there is another flexed layer rather faintly indicated."

Assuming the accuracy of Prof. Dana's data, which I am doing throughout this paper, I find myself unable to accept his inferences. He considers that the phenomena just described confirm his theory; but, with deference to the opinion of so eminent a scientist, I venture to maintain that they more justly fit the theory of intrusion. It is not unusual for schists to undergo increased contortion at the contact with a large intrusive mass. I have described cases of this in my paper on Donegal.[2] This fact suits me quite as well as Prof. Dana. The production of secondary minerals I have also noticed at and near the contact of granite and schist (*loc. cit.*). The composition of these minerals would of course depend upon the composition of the surrounding masses, but at Dunlewy one of the contact-minerals was "allied to kyanite," and therefore not far removed from staurolite. Heated waters, soaking through granite or schist, could hardly fail to give rise to chemical changes in the other rock, and these would under favourable conditions reach to a considerable distance from the line of contact. Mica-schist could obviously cause little change in other rocks; but the felspar and hornblende in the granite and diorite would readily furnish materials for the production of such minerals as kyanite, staurolite, and some garnets. The abundance of quartz-veins tells strongly in favour of my view, the silica set free in the genesis of the basic minerals being redeposited.

The "flexed layer rather faintly indicated" demands special attention. According to Prof. Dana, it is a bed which originally "approached somewhat the granite in character, but which, owing to the nature of its material, was not wholly obliterated." To the enquiry whether such masses may have been fragments of schist entangled in the granite, Prof. Dana replies that "they lie so conformably to the flexures of the" main body of "schist as to suggest a negative reply." He rightly attaches great importance to this parallelism of strike,

[1] The italics are Professor Dana's.

[2] Quart. Journ. Geol. Soc, May, 1885, pp. 225, 226.

He sees that it is the key of his position. Referring (p. 163) to certain masses of schist in granite, he says:—"Since it is obviously impossible that the inclusions taken in and carried up by rocks erupted through deep fissures should be beds of schist 100 to 200 feet long, and a series of such beds separated by the fused rock retaining together their parallel position, we have to admit that these indications of bedding are of *unobliterated*[1] bedding."

In the year of the publication of these views (1881), I first saw the tremendous Highland earth-thrusts, and every succeeding season has taught me more of the wonderful results of earth-pressures. Other workers have been under instruction in the same school; so that some things which seemed impossible in 1881 have, in 1887, become not only possible, but credible. In the light of recent discovery, I venture to suggest that the parallel structure described by Prof. Dana is susceptible of explanation on the theory of intrusion. Igneous rocks forced upwards by tangential pressure would necessarily follow the lines of least resistance. These lines might be planes of cleavage or jointing, or, in the case of some schists, seams of soft mineral matter, such as mica or chlorite. We are here concerned with mica-schists, in which we should naturally expect intrusion to correspond with foliation. From this consideration alone, it would therefore seem that the strips of schist lying between intrusive bands would be approximately parallel. But we have not taken into account the horizontal pressure. This cause would produce parallelism even if it did not previously exist. It would compel flattened fragments, lying pell-mell in a plastic ground-mass, to arrange themselves in planes parallel to each other. The size of the fragments would be quite immaterial. The forces which, in the North of Scotland, sent a mass as large as the County of Rutland sliding up-hill for more than a mile, would take small account of little strips, "100 to 200 feet long," lying immersed in a granitic magma.

But I am not indulging in mere speculation. In Donegal, I often saw outlying masses of schist immersed in granite, and in some districts their foliation was regularly parallel to the foliation of the region. In these cases, Prof. Dana's theory was clearly inapplicable; for the junctions between schist and granite were quite sharp, and the mineral variations sometimes observed at junctions indicated, not a gradation of conditions, but contact alteration. Similar cases were also seen in Connemara. Even in hand-specimens, the parallelism of mineral folia was conspicuous; but, under the microscope, the boundaries of the schist-fragments were perfectly defined. Considerable changes, however, had been produced in the enclosing granite, secondary mica and other minerals having originated at the junctions.

Many other points of great interest are discussed in Prof. Dana's papers; but some are not essential to my argument, and others are hardly ripe for adequate debate.

[1] The italics are Prof. Dana's.

VI.—On a New Species of *Holocentrum* from the Miocene of Malta; with a List of Fossil Berycidæ hitherto Described.

By A. Smith Woodward, F.G.S., F.Z.S.,
of the British Museum (Natural History).

VERY little information has hitherto been published in regard to the fossil fishes of the well-known Miocene formation of the Maltese Islands. Dr. Leith Adams enumerates [1] seventeen species in his latest contribution to the subject, but these are almost exclusively founded upon detached teeth. It is, therefore, of considerable interest to be able to place on record the discovery of a new and tolerably complete fish, obtained from an excavation made some months ago for new docks in the harbour of Valetta.

The fossil in question has lately been received by the British Museum from the Marquis of Lorne, who is of opinion that it was derived from a horizon referable to division No. 4 of the section described in Leith Adams' "Notes of a Naturalist in the Nile Valley and Malta," p. 138. The right side of the fish is exposed to view, showing the general outline of the body; and its salient features are sufficiently well displayed to allow of its certain determination. Unfortunately, however, the bones of the head and pectoral arch are almost entirely broken away; and the right pectoral fin is likewise destroyed, while the left remains inextricably buried in the matrix. One of the pelvic fins, and the right "pelvic" bone, are beautifully preserved. The caudal fin is equally well shown, and the dorsal and anal, though somewhat mutilated, are also recognisable. For a small extent anteriorly, there is a good view of the external surface of the scales of the right side, but posteriorly both the scales of this side and the axial skeleton are removed, so that the left dermal covering is extensively exposed from within.

The specimen must have originally measured about 0·33 m. in total length, and its greatest depth, beneath the anterior part of the dorsal fin, is 0·125 m. The deep, laterally compressed body rapidly narrows posteriorly, leaving a long caudal pedicle, which commences just behind the termination of the dorsal and anal fins, and is about 0·04 m. in length.

Proceeding to the more technical points, there is nothing worthy of note in the axial skeleton, which has mostly been destroyed. Of the appendicular skeleton, the right "pelvic" bone may be observed: it is very robust, gradually widening proximally, and exhibits a prominent median longitudinal rising on its exterior lateral aspect. Correspondingly robust is the pelvic fin. The most anterior ray is a strong spine, sharply pointed at the extremity, and marked by well-defined, more or less obliquely placed ribs. This is followed by seven, or perhaps eight, equally powerful rays, similarly ornamented at their base, but divided distally.

Of the median fins, the dorsal seems to have been divided into two

[1] A. Leith Adams, "On Remains of Mastodon and other Vertebrata of the Miocene beds of the Maltese Islands," Quart. Journ. Geol. Soc. xxxv. (1879), pp. 527-529.

portions, the anterior being the longer and spinous, the posterior consisting entirely of soft rays. The spines are remarkably stout, ornamented with oblique ridges, and diminishing backwards; and at least six are preserved, though appearances are suggestive of others having been broken away in front. Of the soft rays, seven can be distinguished, and these were evidently succeeded by a few more now slightly indicated. Both parts of the fin are comparatively low, but the soft rays originally exceeded the height of the spinous portion. The anal fin is only shown partially, and as a faint impression. Anteriorly there are traces of powerful ribbed spines, supported upon strong interspinous bones, and these are succeeded by at least ten other rays, probably all soft and divided. The total length of the fin is 0·06, and it seems to terminate exactly opposite the posterior extremity of the opposing dorsal. At the base of the caudal fin, both above and below, there are two or three small smooth spines; and in each half of the fin, which is but slightly forked, there are thirteen dichotomous rays, which become closely jointed and commence to branch near the base, ending in very delicate terminal filaments.

Impressions of opercular bones show that these were ornamented to some extent with fine ridges, and small backwardly-directed spines; and the exposed enamel-like surface of each scale is marked anteriorly by a slight rugosity, passing behind into radiating furrows, with intervening ridges, which terminate in the points of the ctenoid border. The scales are very large and thick, having a vertical measurement, in the front portion of the body, of 0·025—0·028, and a total breadth of 0·012. They are deeply overlapping, the covered surface being destitute of the enamel layer, and exhibiting delicate concentric lines of growth.

Such being the main characters of the fossil, it remains to determine its systematic position.

The nature of the dorsal and anal fins, and the situation of the pelvics, are features at once referring the fish to the Acanthopterygian suborder. The relations of the median fins, moreover, and the presence of more than five divided rays in each of the pelvic pair, indicate its affinities still more precisely, and prove it to belong to the family of Berycidæ.

The characters of the dorsal fin determine, further, the generic position of the fish. The separation of the spinous portion of the dorsal from the soft portion, is a feature only met with in two known genera of the family in question, namely, *Myripristis* and *Holocentrum*. From the former, the Maltese fossil differs in having the two divisions more closely approximated, and in this respect it agrees exactly with *Holocentrum*. Its general aspect, also, is very suggestive of the latter genus, and the impression of the anal fin may well be interpreted as showing a great development of the third spinous ray. We may, therefore, safely conclude that we are dealing with a Miocene representative of this well-known surface fish of the present tropical seas.

With regard to specific characters, a careful comparison soon

reveals a divergence from all the forms of *Holocentrum* as yet known. Only one extinct species appears to have been hitherto described, namely, the little *H. macrocephalum*, de Blainv. (=*H. pygmæum*, Ag.), from the Eocene of Monte Bolca, near Verona. This is readily distinguished by its more elongated shape, relatively smaller scales, and the presence of a large spine in advance of the soft rays in the posterior division of the dorsal fin. Twenty-four of the twenty-six recent species enumerated by Dr. Günther [1] are also separated, among other characters, by the greater elongation of the body and the relatively smaller size of the scales; and the remaining two short-bodied types—*H. spinosum* and *H. retrospinis*, from West Indian seas—though very similar in proportions, and apparently with a corresponding opercular armature, have much more strongly serrated scales, and are of considerably smaller dimensions. It is proposed accordingly to designate the Maltese species *H. melitense*.

In conclusion, it may be of value to append a list of the fossil Berycidæ hitherto described. Since the earlier works, numerous emendations and additions have been made to our knowledge of the subject, and some genera and species at first supposed to be rightly placed with this family, are now known to be truly referable to other groups. The determinations here enumerated are such as are adopted in the latest memoirs, and to each species is added the name of the formation and country or district whence the type-specimen was obtained.

Acrogaster, Agassiz.

——— *brevicostatus*, v. der Marck, Palæontogr. vol. xi. p. 24, pl. 7, fig. 2. Cretaceous, Westphalia.

——— *minutus*, v. der Marck, *ibid.* p. 23, pl. 7, fig. 1. Cretaceous, Westphalia.

——— *parvus*, Ag., Rech. Poiss. Foss. vol. iv. p. 134, pl. 17, fig. 2. W. v. der Marck, Palæontogr. vol. xi. p. 23. Cretaceous, Westphalia.

Berycopsis, Dixon.

——— *elegans*, Dixon, Geol. and Foss. Sussex (1850), p. 372, pl. 35, fig. 8. Cretaceous, England.

Beryx, Cuvier.

——— *dalmaticus*, Bassani (Steindachner), Denkschr. Math.-Naturw, Cl. kais. Akad. Wiss., vol. 45 (1882), p. 70. Originally described in error as obtained from the Isle of Lesina, under the name of *B. lesinensis*, Steind., Sitzb. kais. Akad. Wiss. vol. 47 (1863), pt. 1, p. 128, pl. 1. fig. 1. Cretaceous, Dalmatia.

——— *dinolepidotus*, Fischer de Waldheim, Bull. Soc. Imp. Nat. Moscou, 1841. p. 465, pl. 8. Cretaceous, Russia.

——— *insculptus*, Cope, Proc. Amer. Phil. Soc. 1869, p. 240; and "Vert. Cret. Form. West," 1875, pl. 52, fig. 4. Cretaceous, United States.

——— *lewesiensis*: *Zeus lewesiensis*, Mantell, Geol. Sussex, 1822, p. 234, pls. 35, 36. *Beryx ornatus*, Ag. *op. cit.* iv. p. 115, pl. 14*a*; pl. 14*b*, figs. 1 and 2; pl. 14*c*, figs. 1-6; pl. 14*d*. Also Dixon, *op. cit.* p. 371, pl. 36, fig. 3; pl. 34, figs. 1, 4 and 5. Cretaceous, England.

——— *microcephalus*, Ag. *op. cit.* iv. p. 119, pl. 14*b*, figs. 3-6; pl. 14*c*, fig. 10. Dixon, *op. cit.* p. 372, pl. 34, fig. 3. Cretaceous, England.

——— *ovalis*, J. W. Davis, Trans. Roy. Dublin Soc. [2] vol. iii. 1887, p. 508, pl. 27, fig. 4. Cretaceous, Lebanon.

——— *radians*, Ag. *op. cit.* iv. p. 118, pl. 14*b*, fig. 7; pl. 14*c*. figs. 7-9. Dixon, *op. cit.* p. 371, pl. 36, fig. 4. Cretaceous, England.

——— *subovatus*, Bassani, Denkschr. Math.-Naturw. Cl. kais. Akad. Wiss. vol. 45 (1882), p. 34, pl. 8, fig. 4. Cretaceous, Isle of Lesina, Dalmatia.

[1] A. Günther, Cat. Fishes Brit. Mus. vol. i. pp. 28-50.

BERYX *vexillifer*, Pictet, Poiss. Foss. M. Liban, 1850, p. 8, pl. 1, fig. 1. Pictet et Humbert, Nouv. Rech. Poiss. Foss. M. Liban, 1866, p. 30, pl. 2, figs. 1-3. Cretaceous, Lebanon.

HOLOCENTRUM, Artedi.

——— *macrocephalum*, de Blainville, Nouv. Dict. d'Hist. Nat. vol. 27 (1818), p. 349. *H. pygmæum*, Ag., *op. cit.* iv. p. 107, pl. 14; pl. 15, fig. 1. Eocene, Monte Bolca, Verona.

——— *melitense*, A. S. Woodw., 1887. Miocene, Malta.

HOMONOTUS, Dixon.

——— *dorsalis*, Dixon, *op. cit.* p. 372, pl. 35, fig. 2. Cretaceous, England.

——— *pulcher*, Davis, *loc. cit.* p. 519, pl. 25, fig. 3. Cretaceous, Lebanon.

HOPLOPTERYX, Agassiz.

——— *antiquus*, Ag. *op. cit.* iv. p. 131, pl. 17, figs. 6-8. W. v. der Marck, Palæontogr. xi. pp. 13, 14, pl. 1, fig. 4; pl. 2, fig. 1; *ibid.* xxxi. p. 243. Cretaceous, Westphalia.

——— *gibbus*, v. der Marck, Palæontogr. xi. p. 15, pl. 1, figs. 5, 6. Cretaceous, Westphalia.

——— *oblongus*, Davis, *loc. cit.* p. 515, pl. 25, fig. 1. Cretaceous, Lebanon.

——— *spinosus*, Davis, *loc. cit.* p. 516, pl. 28, fig. 1. Cretaceous, Lebanon.

——— *superbus*, Davis, *loc. cit.* p. 514. *Beryx superbus*, Dixon, *op. cit.* p. 372, pl. 36, fig. 5. Cretaceous, England.

——— *syriacus*, Davis, *loc. cit.* p. 514. *Beryx syriacus*, Pictet et Humbert, *op. cit.* p. 28, pl. 1. Cretaceous, Lebanon.

——— *Zippei*, Davis, *loc. cit.* p. 514. *Beryx Zippei*, Ag. *op. cit.* iv. p. 120, pl. 15, fig. 2. Reuss, Verst. böhm. Kreideform. 1845, pt. 1, p. 12, pl. 1; pl. 2, fig. 1. Fritsch, Rept. u. Fische böhm. Kreideform. 1878, p. 41, pl. 5, fig. 1. Cretaceous, Bohemia.

MYRIPRISTIS, Cuvier.

——— *homopterygius*, Ag. *op. cit.* iv. p. 112, pl. 15, fig. 3. Eocene, Monte Bolca, Verona.

——— *leptacanthus*, Ag. *op. cit.* iv. p. 111, pl. 15, fig. 4. Eocene, Monte Bolca, Verona.

PRISTIGENYS, Agassiz.

——— *macrophthalmus*, Ag. *op. cit.* iv. p. 136, pl. 18, fig. 2. Eocene, Monte Bolca, Verona.

PSEUDOBERYX, Pictet et Humbert.

——— *Bottæ*, Pict. et Humb. *op. cit.* p. 34, pl. 2, fig. 7. Cretaceous, Lebanon.

——— *grandis*, Davis, *loc. cit.* p. 510, pl. 28, fig. 4. Cretaceous, Lebanon.

——— *longispinus*, Davis, *loc. cit.* p. 511, pl. 25, fig. 2. Cretaceous, Lebanon.

——— *syriacus*, Pict. et Humb. *op. cit.* p. 33, pl. 2, figs. 4-6. Cretaceous, Lebanon.

SPHENOCEPHALUS, Agassiz.

——— *cataphractus*, v. der Marck, *loc. cit.* xi. p. 18, pl. 3, fig. 1; pl. 7, figs. 3-5. Cretaceous, Westphalia.

——— *fissicaudus*, Ag. *op. cit.* iv. p. 129, pl. 17, figs. 3-5. W. v. der Marck, *loc. cit.* xi. p. 17, pl. 3, fig. 2. Cretaceous, Westphalia.

STENOSTOMA, Dixon.

——— *pulchella*, Dixon, *op. cit.* p. 373, pl. 36, fig. 2. Cretaceous, England.

Among other forms originally included in the Berycidæ may be particularly mentioned the genera *Platycormus*, *Acanus*, *Podocys*, and *Rhacolepis*. The type-species of the first of these was described by Agassiz under the name of *Beryx germanus*, and removed to the Squamipinnes, in 1858, by W. von der Marck,[1] under the new generic title. The most recent researches upon *Acanus* and *Podocys*[2]

[1] W. v. der Marck, "Ueber einige Wirbelthiere, Krusten, und Cephalopoden der Westfälischen Kreide," Zeitschr. deutsch. geol. Gesell. vol. x. 1858, p. 251. See also papers in Palæontographica, vols. xi. xv. xxxi.

[2] A. Wettstein, "Ueber die Fischfauna des Tertiaeren Glarnerschiefers" (Mém. Soc. Pal. Suisse, 1886), pp. 62, 69.

appear to show that the first is a true Percoid, and the second probably the same; while there can be no longer any doubt that *Rhacolepis* is a physostomous fish, having its nearest living ally in the clupeoid genus *Elops*.[1] It may also be added that *Beryx niger*, Costa,[2] from the Cretaceous of Mount Lebanon, is undoubtedly a *Pycnosterinx*.[3]

VII.—On the Tertiary Flora of Australia.

By Dr. Constantin Baron von Ettingshausen, F.C.G.S.,
Professor of Botany, University of Graz, Austria.

MR. C. S. WILKINSON, Government Geologist for New South Wales, had the kindness to entrust his collection of Australian Tertiary plant-remains to me, for which I now express my most sincere thanks to him. I laid the results of my investigations before the Imperial Academy of Sciences of Vienna, in a Memoir, entitled: "Contributions to the Tertiary Flora of Australia, Part II.," which follows a Memoir already published under the same title, Part I., in the forty-seventh volume of the "Denkschriften" of the same Academy.

It is highly satisfactory to me that the general results I obtained from my first efforts were not alone strengthened, but materially completed by the second Part. The 128 species of fossil plants described and figured in it mostly come from Vegetable Creek, near Emmaville, in New England, N. S. W. Twenty-one species have been collected from Elsmore, and only five species from Tingha, in New England. Mr. Wilkinson, who has examined these localities, referred them to the Lower Tertiary formation. The species are distributed into 36 orders and 72 genera. Of the former 35, and of the latter 52, are also represented in the Tertiary Flora of Europe. Respecting the principal sections of the Vegetable Kingdom the Cryptogamæ contain 2 species, the Gymnospermæ 12, the Monocotyledons 2, the Apetalæ 56, the Gamopetalæ 11, and the Dialypetalæ 40. Of the orders represented by several species, the Proteaceæ contain 20 species, the Cupuliferæ 14, the Coniferæ 11, the Myrtaceæ 10, the Laurineæ 7, the Leguminosæ 6, whereas the Moreæ, Apocynaceæ, and Celastrineæ contain 5 species each.

The results respecting the character of the Flora confirm Mr. Wilkinson's statement. We cannot find any reason for supposing the above-named localities to be different in age. It is at first sight evident that the character of their flora (especially of that of Vegetable Creek and of Elsmore) deviates strikingly from the character of the living Australian Flora. According to the latter difference, which indicates a greater divergence of age between both these floras, as well as regarding the close relationship of some

[1] Smith Woodward, "On the Fossil Teleostean Genus *Rhacolepis*," Proc. Zool. Soc. June 23rd, 1887.

[2] O. G. Costa, "Descrizione di alcuni Pesci fossili del Libano," Mem. R. Acad. Sci. Napoli, vol. ii. 1855, p. 100, pl. ii. fig. 1.

[3] Pictet and Humbert, "Nouv. Rech. Poiss. Foss. Liban," p. 43.

of the species to those of the Eocene and of the Cretaceous period, we may conclude that the Fossil Flora described in the above-mentioned memoir might be referred to the Lower Eocene.

When we take into consideration only those fossil species which are represented by fruits, seeds, and characteristic forms of leaves, we obtain new and sufficient proofs concerning the view which I have brought forward in the first part of these contributions, that the elements of the floras are mixed together in the Tertiary Flora of Australia. These proofs consist of facts relative to the common appearance of the genera endemic in Australia with genera we find represented in other floras, but which are strange to the Australian one. For example, there occur in the Fossil Flora of Vegetable Creek and Elsmore the following genera of the Australian element: *Phyllocladus, Casuarina, Santalum, Persoonia, Grevillea, Hakea, Lomatia, Banksia, Dryandra, Callicoma, Ceratopetalum, Pomaderris, Boronia* and *Eucalyptus*. On the other hand we find here, intermixed with the former, types belonging to: *Sequoia* (California), *Myrica* (Europe, North America, Asia, South Africa), *Alnus* (Northern Hemisphere), *Quercus* (Northern Hemisphere), *Cinnamomum* (Asia), *Sassafras* (North America and East India), *Aralia* (North America, Japan and New Zealand), *Elæocarpus* (Tropical Asia), *Acer* (Northern Hemisphere), *Copaifera* (Tropical America). In Part I. of the Contributions quoted above I have already stated that the elements of the floras are united not only in the Tertiary Flora of Europe, of the Arctic Regions, of North America and of Australia, but also in the Tertiary Floras of the other portions of the globe. The above-mentioned facts confirm this even more strongly. Besides, I am able to state the same result from facts which I obtained by examining the Tertiary Flora of New Zealand, with collections of which Prof. (now Sir) Julius von Haast and Prof. T. J. Parker have kindly forwarded to me.[1]

There is now scarcely any doubt that the general character of all Tertiary Floras of the globe is one and the same in regard to the mixture which they exhibit, and continued so until the separation of the elements of floras into the existing special floras towards the commencement of the present period.

The relationship of all the Tertiary Floras of the globe to one another is based upon the common elements of floras. The comparison of the Australian Tertiary Flora to the European one shows at once not only many orders and genera which are common to both, but also many species of the one are more or less corresponding to species of the other. For example the following species are closely related; *Callitris prisca* is closely related to *C. Brongniarti*, *Sequoia Australiensis* to *S. Langsdorfii*, *Podocarpus præ-cupressina* to *P. elegans*, *Casuarina Cookii* to *C. sotzkiana*, *Alnus MacCoyi* to *A. Kefersteinii*, *Quercus Wilkinsoni* to *Q. chlorophylla*, *Q. Hartogi* to *Q. drymeja*, *Fagus Benthami* to *F. Feroniæ*, *Ficus Gidleyi* to *F. arcinervis*, *F. Solanderi* to

[1] A Notice of the Palæo-Botanical Investigations of the Fossil Flora of New Zealand will follow.

F. Reussii, *F. Willsii* to *F. Jynx*, *Cinnamomum polymorphoides* to *C. polymorphum*, *C. Leichardtii* to *C. spectabile*, *C. Nuytsii* to *C. lanceolatum*, *Grevillea proxima* to *G. hæringiana*, *Banksia Lawsoni* to *B. Deikeana*, *B. Hovelli* to *B. hæringiana*, *B. myricæfolia* to *B. Ungeri*, *Dryandra Benthami* to *D. acutiloba*, *Callicoma primæva* to *C. pannonica*, *Ceratopetalum MacDonaldi* to *C. bilinicum*, *Elæocarpus Muelleri* to *E. Albrechti*, *Acer sub-productum* to *A. trilobatum*, *A. sub-integrilobum* to *A. integrilobum*.

I have selected the following few from among numerous new forms, as possessing greater interest. A remarkable *Anomozamites*-species, related to an *Anomozamites* of Greenland, indicates some affinity of the flora to that of the Cretaceous period. *Heterocladiscos*, a *Cupressinea*, shows dimorphous branchlets, the primary ones being cylindrical, their leaves lanceolate, close to one another in spiral order; the secondary ones being four-edged and their leaves rhomboidal-ovate, imbricate and set in four rows. Thus this remarkable plant combines the facies of *Glyptostrobus* with that of *Thuites Mengeanus*, a *Cupressinea* from the amber. Most remarkable is the appearance of *Pseudo-Pinus*, a representative genus of *Pinus*, which perhaps might be even a subgenus of *Pinus*. Cones, seeds, leafed branchlets, rachis of branchlets and single leaves have been found at Vegetable Creek. The cones are smaller than those of any living *Pinus*-species. The size and form of the leaves, as well as their arrangement, and the shape of the branchlets, remind us of *Pinus canadensis*. Besides *Phyllocladus* two separate genera bearing phyllodes also occur at Vegetable Creek, *Palæocladus*, the primary branchlets of which are also phyllodineous, and *Ginkgocladus*, a genus common also to the fossil flora of New Zealand, and combining the facies of *Phyllocladus* with that of *Ginkgo*. A *Sassafras*-species has affinity to Cretaceous species as well as to an Eocene one of the European Tertiary Flora, and points to an early state of the Tertiary Flora to which our flora belongs. The same fact may be admitted respecting some *Aralia*-species. Examples regarding the attachment of our (Australian) flora to that of the Cretaceous period appear, however, to be only isolated when we take into consideration its numerous analogies to known Tertiary plants. *Diemenia*, a peculiar genus of Laurineæ, uniting the facies of *Cinnamomum* with that of other Laurineæ (*Laurus*, *Persea*), occurs in Elsmore, where two species have been collected.

Besides Proteaceæ showing their Australian type, the appearance of *Rhopala*, a genus of tropical America, is remarkable. It is represented in the beds of Vegetable Creek by two species. Not less worthy of note is the appearance of *Banksia*-types exhibiting leaves which are acuminate at their apex, and thus are closely allied to the *Banksia*-species of the European Tertiary Flora. Two species of *Boronia*, an Australian genus, have been found, one of which unites distinctly the characters of two living species. Doubtlessly they have been differentiated from this ancestral species. A calyx in some degree corresponding to those of *Getonia* of the European Tertiary Flora possesses a special interest.

It may be worthy of notice that *Fagus*, distributed over both Hemispheres, is represented in Vegetable Creek not only by types of the Southern, but also by one of the Northern Hemisphere. Whilst the former, belonging to the section *Notofagus*, exhibits coriaceous and persistent leaves, the latter closely corresponds to *Fagus ferruginea*, a species of the section *Eufagus*, bearing membranaceous and deciduous leaves. In accordance with these facts the representation of *Quercus* in the Tertiary Flora of Australia might be considered not less interesting. They have collected in Vegetable Creek leaf-fossils of *Quercus*, belonging to species which are analogous to species now living in North America, in Mexico, on Lebanon, in East India, in Japan, and in the Isle of Hong-kong. Whilst types of *Fagus* are still existing in the present flora of Australia, those of *Quercus* seem to be quite extinct there.

Although the Tertiary Flora of Australia deviates very much from the living one, we find numerous points of connexion between them. A species of *Callitris* closely approaches the *C. robusta*, R. Brown; a *Dammara*-species is very near to *D. australis*, Lamb.; a *Phyllocladus*-species, which on one side unites the characters of all the three living ones, is allied on the other side to types of Mesozoic, especially Cretaceous floras; the genera *Casuarina*, *Santalum*, *Boronia*, *Eucalyptus*, the *Proteaceæ*, *Saxifragaceæ*, etc., are represented by species, more or less closely related to living Australian forms.

A brief synopsis of the conclusions drawn from the general results which the investigation of the Tertiary Flora of Australia have offered may be given as follows :—

Firstly.—The geographical distribution of plants in Australia at the Tertiary period deviated in many respects from the present one. Therefore, the materials for comparison obtainable from the present flora of Australia are not at all sufficient for the investigation of the Tertiary one, and must consequently be completed from other floras of the globe.

Secondly.—Types of plants of the Southern as well as of the Northern Hemisphere of the globe are associated together in the Tertiary Flora of Australia.

Thirdly.—The flora-elements represented in the Tertiary Flora of Australia chiefly contain Phylones (ancestor-types), which are also common to other Tertiary Floras of the globe. The character of the Tertiary Flora of Australia cannot therefore be considered essentially different from that of the latter.

Fourthly.—The Australian Tertiary Flora, in accordance with the preceding statements, is but a part of one and the same Original-flora upon which all living floras of the globe are founded.

Fifthly.—The comparison of this Original-flora to the present floras of the globe shows that in Australia the differentiation of the Phylones has reached its highest degree.

Sixthly.—Many analogies to the Tertiary Flora are nevertheless to be found in the living Australian Flora.

VIII.—On the Fossil Flora of New Zealand.

By Dr. Constantin Baron von Ettingshausen, F.C.G.S.,
Professor of Botany, University of Graz, Austria.

IT was my good fortune in 1884 to receive two interesting collections of fossil plants from New Zealand, for which I am indebted to the kindness of Professor (now Sir Julius) von Haast, of Christchurch, and Professor T. J. Parker, of Dunedin. In these collections seventeen localities of fossil plants are represented which belong to three formations: the Tertiary, the Cretaceous, and the Triassic formations.

The relation of the living flora of New Zealand to its Tertiary one has already formed the subject of a paper submitted by me to the Imperial Academy of Sciences in Vienna, under the title "Genetische Gliederung der Flora Neuseelands" (Sitzungsberichte vol. 58, part i. p. 953). I have pointed out in it that the endemic New Zealand flora not only contains types which may probably descend from the principal element of its Tertiary Flora, but also such ones probably being derivable from some accessory elements of the latter flora.

Only a brief time has elapsed since my attention has been again drawn to the subject, and I have been enabled by the examination of the above-mentioned collections to lay a Memoir before the Vienna Academy, entitled: "Contributions to the Fossil Flora of New Zealand" (Denkschriften, vol. 53, part 1, 1887), of which I now have the pleasure to give a brief account.

The Tertiary Flora of New Zealand, collected from eight localities, as Shag Point, Dunstan, Landslip Hill, Malvern Hills, Racacliff Gully, Weka Pass, Amuri and Murderer's Creek, comprises till now as far as investigations could bring to light, 52 species which are distributed into 39 genera and 26 families. Of these species 3 are Cryptogamæ, 11 Gymnospermæ, 2 Monocotyledons, 22 Apetalæ, 3 Gamopetalæ and 10 Dialypetalæ. Regarding the general character of the flora, it by no means essentially deviates from that of the hitherto known Tertiary Flora. We find here the same mixed character as in the Tertiary Flora of Europe, of North America, and of Australia, the analogies of which to the New Zealand Tertiary species may easily be surveyed in a table appended to the above-mentioned Memoir.

Although the Tertiary Flora of New Zealand is very different from the living one, yet with regard to several species a close relationship is clearly indicated between them. Thus, *Aspidium tertiario-zelandicum* and *A. Novæ-Zelandiæ*, *Dammara Oweni* and *D. australis*, Lamb., *Podocarpus Parkeri* and *P. Totara*, Don., *Decrydium præ-cupressinum* and *D. cupressinum*, Sol., etc., are closely allied. Besides several genera, for instance, *Fagus*, *Hedycarya*, *Santalum*, *Loranthus*, etc., are represented in both, whereas others seem to be in a genetic relation to living ones, and the latter may in some degree be transmuted from the former. Thus, *Daphnophyllum* or

Laurophyllum may have been evolved from *Nesodaphne*, likewise *Apocynophyllum* from *Parsonsia*, *Aralia* from *Schefflera*, *Sapindus* from *Alectryon*, etc. On the contrary, we miss in the recent endemic flora of New Zealand a considerable series of genera belonging to its Tertiary flora, for instance: *Lomariopsis*, *Sequoia*, *Araucaria*, *Seaforthia*, *Casuarina*, *Myrica*, *Alnus*, *Quercus*, *Ulmus*, *Planera*, *Ficus*, *Cinnamomum*, *Dryandra*, *Diospyros*, *Aralia*, *Acer*, *Sapindus*, *Elæodendron*, etc.

According to the preceding statements, the principal results of my memoir are as follows:—

Firstly.—In New Zealand there exists a genetic relationship between its Tertiary and its living flora.

Secondly.—The Tertiary Flora of New Zealand contains the elements of floras.

Thirdly.—The Tertiary Flora of New Zealand is a part of that universal Original-flora from which all living floras of the globe descend.

Fourthly.—In New Zealand only one part of its Tertiary Flora has changed into its living flora, the other has become extinct.

I proceed now to give a brief record of the fossil plants occurring in the above-named localities.

I. Of all the localities ascribed to the Tertiary formation, that of Shag Point is the richest and most interesting. Of Cryptogamæ two species of *Aspidium*, and of *Cycadeæ* one specimen, betraying some resemblance to *Zamites tertiarius*, Heer, have been found there. Of Coniferæ 10 species have been discovered there, belonging to 7 genera. Of Monocotyledons one *Caulinites* species, and of Dicotyledons a considerable series occur there, namely:—One *Casuarina* species; two species of *Myrica*, the one allied to *M. integrifolia*, Ung., of the European Tertiary Flora, the other similar to *M. quercifolia*, L., a native of the Cape of Good Hope; one *Alnus* species, closely allied to the European Tertiary, *A. Kefersteinii*, as well as to the Australian Tertiary *A. MacCoyi*, M.; four *Quercus* species, one of them related to *Q. macranthera*, native of the Caucasus, another allied to the European Tertiary *Q. lonchitis*, Ung.; two species of *Fagus*, the one related to *F. procera* and *F. alpina*, both natives of Chili; the other very similar to *F. Deucalionis*, Ung., as well as to the North American *F. ferruginea*. One *Ulmus* and one *Planera* species, both analogous to species of the European Tertiary Flora; one *Ficus* species corresponding to *F. lanceolata* of the European Tertiary, and to *F. Burkei*, m., of the Australian Tertiary Flora; one *Hedycarya* species, analogous to the Tertiary *H. europeæ*, as well as to the Australian Tertiary *H. Wickami*; one *Cinnamomum* species, closely allied to *C. polymorphum* and to *C. polymorphoides*; two *Cassia* species, the one closely related to *C. phaseolites* and *C. phaseolitoides*, the other to *C. Memnonia*. Besides, species of the genera *Santalum*, *Diospyros*, *Aralia*, *Loranthus*, *Acer*, and *Carpolithes*, their analogues being represented in the Tertiary of Europe, North America, and Australia having been found there.

From the flora of the above-mentioned locality we may safely conclude that it, and probably also the following localities belong to

the Lower Tertiary. As many species of this flora are closely allied, or at least analogous to Eocene species, I refer it to the Eocene Period.

II. From Dunstan the following species are now before us :—One *Lomariopsis* species, analogous to *L. bilinica* from the Eocene strata of Kutschlin, near Bilin, and related to *L. triquetra*, a native of Nepal; the *Aspidium* species which has also been collected from the preceding locality; and one *Seaforthia* species, analogous to *S. Mellingii* of the fossil Flora of Eibiswald, and to *S. robusta*, R. Brown, living in Australia.

III. From Landslip Hill the following came :—The *Sequoia* species also found at Shag Point; one *Dryophyllum* species, being analogous to *D. lineare* from the Eocene Flora of Sézanne; two *Apocynophyllum* species, the one corresponding to *A. helveticum* of the European Tertiary, and to *A. MacKinlayi* of the Australian Eocene Flora, the other related to *A. Tabernæmontana* of the fossil Flora of Radoboj; one *Elæodendron*-species corresponding to *E. helveticum* of the European Tertiary Flora and *E. curtipendulum*, a native of Norfolk Island.

IV. At Malvern Hill I., the following species have been found :—An *Araucaria* and a *Dammara* species, both also occurring at Shag Point; a *Myrica*, representing the widely-spread Tertiary *Myrica lignitum*; a *Quercus*-species coming also from Shag Point; a *Fagus* corresponding to *F. Wilkinsoni* of the Australian Tertiary; a *Planera* which appears also at Shag Point and at Murderer's Creek; a *Cissophyllum*, approaching the genera *Cissites* and *Ampelophyllum*.

V. At Racacliff Gully the following fossil plants have been found: —An *Alnus* and a *Quercus*, both also occurring at Shag Point; a *Sapindus*, corresponding to *S. falcifolius* of the European, and to *S. caudatus* of the American, as well as to *S. Gossei* of the Australian Tertiary Flora.

VI. From Weka Pass, a *Daphnophyllum*-species, related to *D. ellipticum*, Heer, has been collected.

VII. At Amuri a fragment of wood has been discovered. I referred it to *Dammara Oweni*, a species occurring also at Shag Point and at Malvern Hills I.

VIII. At Murderer's Creek the following fossils have been obtained: A *Quercus*, a *Planera*, a *Cinnamomum*, and a *Cassia*, all also collected from the preceding localities I.—V.; a *Dryandra*, closely related to *D. acutiloba* of the European and to *D. Benthami* of the Australian Tertiary Flora.

Taking into consideration that although only a few species have been found at each of the localities Nos. II.—VIII., the plurality of the species is common to them, especially to Shag Point, we may conclude that their flora is to be referred to the same period, being already determined as Eocene.

The strata containing remains of Dicotyledons in New Zealand having been collectively called the "Cretaceo-Tertiary Formation," I have pointed out that some of the strata must be referred only to the Tertiary, and the others only to the Cretaceous formation. Whilst

the former have already been taken into consideration in the preceding exposition, I proceed now to explain the results of my investigations of the fossil Flora of the Cretaceous formation.

The Cretaceous Flora of New Zealand has up till now been collected from four localities, as, Pakawau, Grey River, Wangapeka and Reefton. It contains 37 species, distributed into 29 genera and 17 families. Of these species 4 are Cryptogamæ, 8 Coniferæ, 4 Monocotyledons, 13 Apetalæ, and 8 Dialypetalæ. The Gamopetalæ are wanting here. Several species seem to be the ancestors of Tertiary ones, particularly of the genera *Aspidium, Podocarpus, Dacrydium, Quercus, Fagus, Cinnamomum, Dryandroides, Ceratopetalum, Cupanoides,* etc. According to the closer relationship of some of these species to Tertiary ones, we may refer the above-mentioned localities to the Upper Cretaceous formation.

I. Pakawau, Nelson, the richest locality of the four, contains well-preserved fossil plants. Its flora is characterized by species of ferns exhibiting the facies of Cretaceous ferns; by the genera of Coniferæ *Podocarpium* and *Dacrydinium;* by a peculiar genus of Musaceæ, *Haastia,* related to *Musophyllum;* by *Ulmophylon,* a genus comprising the ancestor-species of Tertiary *Ulmus* and *Planera*-species; by a *Dryophyllum* and by a *Grewiopsis*-species analogous to species of the American Cretaceous formation; and by species of *Cinnamomum* and *Dryandroides,* corresponding to European Cretaceous species. There have also been found a *Bambusea,* a *Casuarinites,* a peculiar *Fagus*-species and a *Cupanites.*

II. Gery River, Westland, a locality which offers many but not such well-preserved fossils. There have been disvovered a *Flabellaria,* related to *F. longirhachis,* Ung., from the Cretaceous beds of Muthmannsdorf, Austria; two species of *Quercus,* one species of *Celastrophyllum* and one species of *Palæocassia,* all corresponding to species of the Cretaceous Flora; a *Dalbergiophyllum* reminds us of a *Dalbergia*-species of the same flora. There also have been found, a *Knightiophyllum* and a *Ceratopetalum,* both peculiar to this locality, whilst a *Bambusea,* a *Casuarinites* and a *Cupanites,* which also occur at the former locality, have been collected.

III. Wangapeka, Nelson, showing a flora which agrees with that of the preceding localities, inasmuch as some of its species are common to the latter. Of the several forms of fossil plants peculiar to this locality, the following are worthy of notice: Two genera of Coniferæ, the one intermediate between *Cephalotaxus* and *Torreya,* the other uniting *Ginkgo* with *Phyllocladus;* two *Quercus,* one *Fagus* and one *Ficus*-species, all corresponding to Cretaceous forms; a *Sapindophyllum* analogous to *Sapindus prodromus,* Heer, from the Cretaceous strata of North Greenland; a *Dalbergiophyllum* and a *Poacites.*

IV. Reefton, Nelson.—Only *Casuarinites* Cretaceous has been found here, a species which also occurs at Pakawau and at Grey River.

The collections of Sir Julius von Haast and Prof. Parker also contain numerous fossil plants from localities which I refer to much lower Mesozoic strata. They are Mount Potts, Haast Gully, Malvern Hills II., Mataura and Waikawa. A greater difference of age of these localities is excluded by some common species which they

contain. The species mostly are analogous to Triassic ones. I may therefore not be far wrong in supposing that all the last-named localities belong to the Trias formation.

A brief record of their flora follows:—

I. *Mount Potts.* Here have been collected:—*Equisetum microdon*, m., a species corresponding to an European-Triassic one; *Tæniopteris pseudo-vittata*, m., closely allied to *T. vittata* from the European Trias-flora; *Asplenium Hochstetteri*, Ung. sp.; *Palissya podocarpoides*, m., analogous to *P. Braunii*, Endl.; *Baiera australis*, m., also corresponding to an European species of that flora; Phyllodes of *Thinnfeldia australis*, m., and of *Protocladus linqua*, m.

II. At *Haast Gully* (also called "Clent Hills") have been found:—*Sphenopteris amissa*, m., *S. Clentiana*, m., *Pecopteris proxima*, m., *Tæniopteris pseudo-simplex*, m., all more or less related to Triassic species, *Tæniopteris pseudo-vittata*, *Camptopteris Haastii*, m., *Asplenium Hochstetteri*, *Equisetum microdon*, *Palissya podocarpoides*, and *Baiera australis*.

III. *Malvern Hills II.* (not to be confounded with the above-named Tertiary locality Malvern Hills I.). *Pecopteris proxima*, m., *Tæniopteris lomariopsis*, m., both related to Triassic species, *Asplenium palæo-darea*, m., *A. Hochstetteri*, *Podozamites Malvernicus*, m., and *Protocladus lingua* have been collected there.

IV. *Matura* and V. *Waikawa*. There have been found:- *Sphenopteris Palæopteris*, Ung. sp., *Hymenophyllites australis*, m., *Tæniopteris pseudo-simplex*, *T. lomariopsis*, *Asplenium Hochstetteri*, *Macro-Tæniopteris affinis*, m., *Lycopodites palæo-selaginella*, m., *Nilssonia Zeelandica*, m., *Zamites Mataurensis*, m., *Pterophyllum Dieffenbachi*, m. The fossil plants are well preserved there, and the species bear more or less the facies of those of the Triassic Flora.

In concluding this brief notice, I have to remark that I am unwillingly compelled to disagree with the view expressed by Sir James Hector, and published by him in "New Zealand Court," Catalogue Indian and Colonial Exhibition, London, 1886, p. 60, namely, that there occur Mesozoic plants in New Zealand, as, for instance, species of *Alethopteris*, *Tæniopteris*, etc., together with leaves of Tertiary Dicotyledons in one and the same strata. I have not seen any trace of such a connexion in the rich material the above-mentioned collections offer. Sir James Hector's statement may be based on some mistake; perhaps, he has taken specimens of *Camptopteris* for leaves of Dicotyledons, an error easily possible when the specimens are not well preserved.

REVIEWS.

I.—A Popular Guide to the Geology of the Isle of Wight, with a Note on its Relation to that of the Isle of Purbeck. By Mark W. Norman. 8vo. pp. 240, Map, Sections, and 15 Plates of Fossils. (Ventnor, 1887.)

MR. MARK NORMAN, who some years ago contributed a paper on the Greensand formation of the Isle of Wight to the Geological Magazine, now presents us with a popular

Geological Guide to the Island. Basing his views upon the excellent works of Mantell, Forbes, Bristow and others, Mr. Norman has incorporated in his volume many descriptive notes and suggestive observations, the result of thirty years' experience and work amongst the Downs and Coast sections of his interesting district. Each geological formation is reviewed in turn, and lists and illustrations of the principal fossils given. Notes on the best collecting grounds, and much information of an instructive and useful kind, both to the collector and visitor, as well as to amateurs and students, will also be found in his pages. After reviewing the various divisions in ascending order, Mr. Norman devotes one chapter to the consideration of "Denudation and Landslips," and another to "The Human Period." In an appendix he discusses "the Relation of the Geology of the Isle of Wight to that of the Isle of Purbeck." Some notes on the Ventnor Museum and a list of the Economic Products of the Island complete the volume.

Although the book is essentially a Geological Guide, Mr. Norman has rendered it useful to other visitors, for he points out the most interesting features in the landscape, and gives much general information touching the antiquities of the Island and other objects.

A map, sections, and fifteen plates of fossils accompany the text, and we must congratulate the author on having so careful a draughtsman as his friend Mr. Ryan, the plates being much superior to those usually seen in Guide-books. Several typographical errors on the plates and others in the text seem to have escaped the notice of the author. The numerous plates and figures together with the low price should recommend this book to all, and it should especially find a place in the equipment of the tourist and the visitor, who is interested in the Geology of the Isle of Wight.

II.—Preliminary Report on some Graptolites from the Lower Palæozoic Rocks on the South Side of the St. Lawrence, from Cape Rosier to Tartigo River, from the North Shore of the Island of Orleans, one mile above Cap Rouge, and from the Cove Fields, Quebec. By Prof. Chas. Lapworth, LL.D., F.G.S. [From the Transactions of the Royal Society of Canada, Section iv. 1886.]

IN his brilliant Memoirs on the Moffat Series and the Girvan Succession, Professor Lapworth completely established the high importance that should be attached to the study of life-zones for the elucidation of the true sequence of fossiliferous rocks. Wherever these rocks are contorted into frequent foldings and their original position disturbed by faults, stratigraphical evidence alone can seldom be relied upon to assign them their place in the series. In such cases the testimony afforded by fossils even of such lowly organization as that of the Graptolites becomes of almost incalculable value.

In complicated areas such as those of the Girvan District, the eastern townships of Lower Canada, and the regions treated of in the Report now before us, a minute and patient investigation of the

life-groups, as they occur in each stratum, is the only method open to the geologist who aspires to lay the foundations for an enduring scheme of classification.

The collection of Graptolites treated of in this Report was forwarded to Prof. Lapworth by Dr. A. R. C. Selwyn, F.R.S., Director of the Geological Survey of Canada, the material having been accumulated by various members of the Staff of the Survey at different periods dating from 1876.

The Graptolites were found to belong to several distinct zones, each corresponding with a distinct zone in Great Britain and Western Europe, and ranging from the British Tremadoc Slates to the middle of the Bala or Caradoc Formation of Wales and the West of England.

The Graptolite zones are here briefly described:—

Zone I.—*Cape Rosier Zone:* Zone of *Dictyonema sociale* and *Bryograptus.*

This is the oldest represented, and it occurs at the Barrasois River, Cape Breton Island, and at Cape Rosier, Gaspé; as well as at other points along the south shore of the St. Lawrence. In Europe it occurs in the Tremadoc of Wales and the Tremadoc and Ceratopyge Beds of Norway (Brögger) and Sweden (Tullberg). It is of Upper Cambrian age.

Zone II.—*Ste Anne Zone:* Zone of *Phyllograptus Anna;* Graptolites from Rocks three miles above Ste Anne des Monts.

This zone contains the following four species of Graptolites; *Tetragraptus bryonoides,* Hall; *T. fruticosus,* Hall; *Phyllograptus Anna,* Hall; *Didymograptus extensus,* Hall. "These are all well-known Point Levis species, according to the classical monograph of Prof. Hall,[1] and they also occur together upon the corresponding Arenig-Skiddaw horizon in Europe, in the Shelve Arenigs, in the Skiddaw Slates, and in the *Phyllograptus* beds of Norway and Sweden."

The author remarks upon the absence of this Ste Anne Phyllograptus zone in the collection among the fossils eastward of the Ste Anne River, though the lithological characters of these strata point to the persistence of such a zone for great distances.

Zone III.—*Griffin Point* or *Marsouin River Zone:* Zone of *Cœnograptus gracilis.*

This supplies the largest number of species in the collection.

The most characteristic forms are *Didymograptus sagittarius* (Hall, non Hisinger); *Cœnograptus gracilis,* Hall; *Dicellograptus sextans,* Hall; *Lasiograptus mucronatus,* Hall; *Climacograptus antiquus,* Lapworth; *Diplograptus Whitfieldi,* Hall, "and the presence of a single one of these species is sufficient to settle the age of the rock in Great Britain, and in all likelihood in America." But there are associated with them a few species which enjoy a more extended range in time, such as the well-known Hudson River form, *Dicranograptus ramosus,* Hall.

[1] Canadian Organic Remains, Decade ii. 1865, "Graptolites of the Quebec Group."

The most important and interesting point in connexion with this Marsouin River zone is its identity with that of the Norman's Kill shales in the Hudson River valley, near Albany, described by Prof. James Hall in the "Palæontology of New York."[1]

The New York geologists have always held that the Norman's Kill beds are of the age of the Hudson River (Lorraine Shales), or of that of the Utica Slate; but Prof. Lapworth observes, "not a shadow of palæontological evidence has yet been adduced to show that these Norman's Kill or Marsouin Rocks are newer than the Trenton." On the whole he regards the Marsouin zone provisionally as coming between the Chazy (holding *Muclurea Logani* and *Ophileta compacta*) and the Trenton Limestone in America, and therefore answering roughly to the *Cænograptus gracilis* zone in Britain, "in age as well as in fossils."

As a result of his analysis of the three Graptolitic zones above detailed, Prof. Lapworth finds that there are two grand faunas represented, viz.:—(A) The so-called Quebec fauna of the Calciferous-Chazy formations of Cape Breton, Cape Rosier, Point Levis and Ste Anne, which answers to the fauna of the British Upper Tremadoc and Arenig rocks and their European equivalents; and (B) the Griffin Cove, Marsouin River, and Norman's Kill fauna, which answers to the fauna of the middle zones of the European Ordovician or Cambro-Silurian rocks.

In each of these grand faunas are found two subfaunas, those of the lower faunas being the more distinctly separable:—

A. Quebec or Calciferous-Chazy Fauna.—Subfauna I.—*Cape Rosier and Barrasois River Zone*, of Calciferous age = Tremadoc Rocks of Great Britain and *Ceratopyge* and *Dictyonema* Beds of Norway.

Subfauna II.—*Ste Anne River Zone*, of Point Levis age = typical Arenig of Great Britain; *Phyllograptus* Beds of Scandinavia, etc.

B. Trentonian, Marsouin River, or Norman's Kill Fauna.—Subfauna *A.*—*The Cænograptus Zone of Griffin Cove and the Marsouin River*, answering to the Middle Llandeilo Beds of Great Britain, to the Glenkiln Beds of Scotland, etc.

Subfauna *B.*—*The Cove Fields and Orleans subfauna;* apparently destitute of *Cænograptus gracilis*, and answering to the highest Llandeilo or lowest Caradoc Beds of England.

The last of these subfaunas shows evidence of a transition into the Utica-Lorraine Graptolitic fauna of the Mohawk Valley, New York, and of Lake St. John, Canada."

The author next presents a "Possible Ascending Succession of Strata, on the South Side of the St. Lawrence, from Cape Gaspé to Tartigo River," which includes

Pre-Cambrian.

(*A*). Metamorphic Rocks of the Shickshock Ranges [in the Gaspé Peninsula].

Cambrian.

(*B*). Cambrian Formations.

Ordovician.

(*C*). Ordovician or Cambro-Silurian Formations.

[1] Vol. i. 1847.

(1). *Lower or Quebec Group of Logan.*
(2). *Middle Division, or Trenton and Black River Rocks of Hall and Logan.*
(3). *Upper Division, or Hudson River and Lorraine Rocks of Hall and Logan (apparently wanting).*

The lithological characters of these groups are described with much minuteness, and their stratigraphical relations discussed. Into these details our space forbids us to enter, but we cannot refrain from quoting from the paragraph in which Professor Lapworth concludes this interesting and suggestive study of Canadian Graptolites.

"In the careful study of the geographical and geological distribution of the several horizons of these Graptolites in the extensive convoluted rock series of the Eastern Townships, lies the solution of the great geological enigma of the Quebec Group and its puzzling associates. We shall not be able to parallel the eastern and western series, formation for formation, until we know more of the Graptolitic fauna of the Chazy, Black River, Trenton, Utica and Lorraine formations themselves, where they lie flat and undisturbed, and can compare them with those of their European equivalents. This is a work that ought to be at once taken up by American geologists, and carried on, stage by stage, with the study of the equivalent rocks of the convoluted eastern areas. Till this is done, all our correlations of these eastern deposits must be regarded simply as provisional approximations, liable to inevitable modification and improvement in the light of future discovery."

The last few pages of the Report are devoted to a "Provisional list of Fossils [*i.e.* Graptolites], with localities," together with two useful tables; Table A. "Showing the various Horizons, approximate Geological Age, and American and European Equivalents of the several Graptolitic Zones," etc. Table B. "Showing Vertical Range of Graptolites from Rocks between Cape Rosier (Gaspé) and Cap Rouge (Quebec)." A. H. F.

REPORTS AND PROCEEDINGS.

I.—The Palæontographical Society of London.

Report of the Council read and adopted at the Annual General Meeting, held at the Apartments of the Geological Society, Burlington House, 17th June, 1887, Dr. Henry Woodward, F.R.S., Vice-President, in the Chair.

THE Council in presenting their fortieth Annual Report take the opportunity of inviting the attention of Members to the publications of the Society and to the faithful manner in which the wishes and purpose of its founders are being carried into effect.

Since the last meeting was called, a volume has been issued—one every way equal to its predecessors, so far as the valuable scientific information contained in it and the beauty of its illustrations are concerned. This book (the return for the Members' subscriptions due in 1886) contains five distinct subjects, four of which form the commencement of new monographs, and one is the continuation of

a Memoir begun twenty years previously. The first on the list, that on the Morphology and Histology of *Stigmaria ficoides*, by Prof. W. C. Williamson, LL.D., F.R.S., is a complete summary of the latest information on the roots and rootlets of the great Carboniferous Sigillaroid trees, and devotes fifteen plates to their aspect, as seen by the aid of the microscope as well as by the unassisted vision. All the plates are examples of high artistic skill, and of excellent lithographic printing.

The second monograph on the list, viz. that on the Fossil Sponges, by Dr. George J. Hinde, F.G.S., deals with a general introduction, and gives much information with regard to the structure and forms of Palæozoic Sponge-spicules. The eight plates accompanying Part I. of this Memoir are fine specimens of careful drawing. In the third work, treating of the Jurassic Gasteropoda, by Wilfrid H. Hudleston, M.A., F.R.S., F.G.S., the variations in the strata of the Inferior Oolite at numerous localities in Dorsetshire and Somersetshire are dwelt upon (the beds themselves being carefully defined), so that when the description of species commences, as will be the case in the next volume, the different horizons can be rigorously indicated. In the fourth Monograph, by S. S. Buckman, F.G.S., the Ammonites of the Inferior Oolite are taken in hand, and five species, illustrated by six admirable plates, are described with much care, an earnest of the nature of the parts that will follow. In the fifth and last work the continuation of the Mammalia of the Pleistocene period, by Professor W. Boyd Dawkins, M.A., F.R.S., F.S.A., F.G.S., the horns of some of the Deer belonging to that era are delineated by seven fine plates.

The cost of this grand volume has exceeded five hundred pounds, and has been more in amount than the sum contributed by the subscribers for the year to which the book relates.

The volume for the year 1887 is with the printer, and will contain the continuation of the Monographs on the Palæozoic Sponges, the Jurassic Gasteropoda, and the Inferior Oolite Ammonites; it will introduce, in addition, a new Monograph on the Palæozoic Phyllopoda, by Prof. T. Rupert Jones, F.R.S., and Dr. H. Woodward, F.R.S.

Dr. H. Woodward has promised, at an early date, a Monograph on the Insects of the Coal-period, for which he has been for some time collecting materials.

Active then as is the Society for the promotion of Palæontological Science, it is a matter of regret, that Geologists in general do not more readily enroll themselves as members. A hundred additional subscribers would materially advance the issue of the Monographs, seeing that several of the latter cannot at the present moment be proceeded with for want of funds. The aim of the Society is essentially national, and is deserving of national support. For forty years the Society has laboured and has outlived all but a very few of its founders and early friends; nevertheless the present year finds it still at work, striving to spread abroad a knowledge of the vast stores of fossil treasures existing in the strata of Great Britain. Since the days that its original promoters met together, many Free

Libraries, local Geological Societies, and Naturalists' Field-Clubs have risen into being, but the number of these institutions that have joined the Society is very small.

Cannot the lovers of geological science be induced to combine and replenish the void places caused, to so large an extent of late years, by the hand of death in the once long list of members of this useful and important Society, whose work cannot be said to be fulfilled so long as any British fossils remain unfigured and undescribed?

II.—Geological Society of London.

June 23, 1887.—Professor J. W. Judd, F.R.S., President, in the Chair.—The following communications were read:—

1. "On Nepheline Rocks in Brazil, with special Reference to the Association of Phonolite and Foyaite." By Orville A. Derby, Esq., F.G.S.

The author refers to the phonolites and associated basalts of Fernando Noronha, a deep-sea island off the north-eastern shoulder of the Continent of South America. Nepheline rocks of a somewhat different character are abundantly developed on the mainland, and under conditions favourable for throwing light on the relations existing between the granitic type, foyaite, and the other members of the group. There are some mountains near Rio de Janeiro composed of these rocks, as is also the peak of Itatiaia, 3000 metres high, the loftiest mountain of eastern South America. A cursory examination of some of these localities having shown an apparent relation between foyaite, phonolite, trachyte and certain types of basalt, Mr. Derby determined to visit the Caldas region, where a railway under construction gave unusual facilities for examining this series. A fine development of foyaite, phonolite and tuff was found, associated with several types that have not yet been met with in the other localities. The existence of a leucite basalt was recognized.

The bulk of the paper was devoted to a detailed description of these railway-sections, and the following deductions are drawn:—

1. The substantial identity, as regards mode of occurrence and geological age, of the Caldas phonolites and foyaites.

2. The connexion of the latter through the phonolites with a typical volcanic series containing both deep-seated and aerial types of deposits.

3. The equal, if not greater antiquity of the leucite rocks as compared with the nepheline rocks, whether felsitic, as phonolite, or granitic as foyaite.

4. The probable Palæozoic age of the whole eruptive series.

2. "Notes on the Metamorphic Rocks of South Devon." By Miss Catherine A. Raisin, B.Sc. Communicated by Prof. T. G. Bonney, D.Sc., LL.D., F.R.S., F.G.S.

This communication consisted mainly of detailed observations, supplementary to those published by Prof. Bonney in the Society's Journal for 1884, on the slaty and metamorphic rocks of South

Devon in the neighbourhood of Salcombe estuary. In the first part of the paper details were given of the sections exposed around the estuary, at Hope Cave to the westward, and in several localities to the eastward as far as Hall Sands, all confirmative of Professor Bonney's views, and showing that the slaty beds to the northward do not pass into the mica and chlorite schists to the south, but are separated from the latter by a line of faults.

Descriptions were then given of microscopic slides from various parts of the metamorphic rocks. Some of these showed the action of secondary forces. The effects of lateral pressure in producing cleavage-planes and a kind of jointing were also commented upon.

An attempt was also made to determine the succession of chlorite-mica- and micaceo-chloritic schists around Salcombe estuary. The beds appeared to succeed each other in the following order, commencing from the northward :—

1. (*a*) Interbanded series south of Halwell Wood, etc.
   (*b*) A thick band of chlorite-schist at Scoble, Snapes Point, etc.
2. (*a*) Mica-schist north of the side estuary.
   (*b*) Interbanded series south of the side estuary.
3. Mica-schist of Portlemouth Ferry.
4. Chlorite-schist of Bickerton.

3. "On the Ancient Beach and Boulders near Braunton and Croyde in North Devon." By Prof. T. McKenny Hughes, M.A., F.G.S.

The author observes that amongst the raised beaches of S.W. England we generally find included the sand cliffs of Saunton Down and Middleborough on the coast west of Barnstaple. These deposits possess a further interest owing to the occurrence at their base of large boulders. In 1866 Mr. Spence Bate, in opposition to the prevailing view, concluded that the so-called raised beach is the undestroyed remnant of an extensive district of wind-borne sand similar to that which now exists on Braunton Burrows. The points to which attention was invited are as follows :—

1. Is this deposit on the southern slope of Saunton Down a raised beach ?

2. Were the above-mentioned boulders carried to their present position by ice ?

The paper was fully illustrated by diagrams, showing the relations of the recent deposit, and by figures showing the mode of occurrence of three of the most remarkable boulders. The conclusions were :— (1) That the ancient beach of Saunton Down and Croyde is not a *raised beach* in the ordinary acceptation of the term. The top is subaerial talus, the middle part is blown sand, the base only marine, and the marine part is not above the reach of the waves of the sea at its present level. (2) The boulders of granite and felsite which occur at the base of the ancient beach were transported to their present position by the waves of the sea. Such as are of local origin could have reached the sea by the ordinary processes of denudation ; such as are possibly of northern origin could have been

carried down the Irish Channel on bergs, and been thrown up by the sea to their present position at any period subsequent to their transportation southwards by ice; but their presence does not imply any *local* glaciation.

4. "Notes on the Formation of Coal-seams, as suggested by evidence collected chiefly in the Leicestershire and South Derbyshire Coal-field." By W. S. Gresley, Esq., F.G.S.

The author's principal object in this paper was to bring forward evidence in opposition to the view now generally accepted that coal-seams were formed from vegetation growing on the spot.

He showed that during a very extensive experience he had only once or twice detected stems passing into a bed of coal and connected with the Stigmaria-roots in the underclay. If, as was generally stated, the Stigmariæ were the roots of the trees that formed the coal, such instances ought to be common. Not only, however, were they very rare, but the abundance of the Stigmariæ was extremely variable, and these roots, instead of becoming more thickly matted together in the uppermost part of the underclay, as they should be if they were roots of the coal-forests, were generally distributed, as a rule, throughout the clay in a manner that showed them to have been in all probability independent organisms. Stigmarian roots, when found connected with a stem, were more often on the top of the coal-seam than at the bottom.

Other reasons assigned for rejecting the hypothesis that coal-seams were formed of plants that grew upon the spot were the occasional absence of underclays, the sharp division between the coal-seams themselves, and the beds above and below them; the distinct lamination of every seam and its division into layers of different mineral character that are persistent over large areas; the presence of foreign bodies in the underclay, and especially of pebbles and boulders transported from a distance; the presence of similar fish, etc., in the coal itself; and the circumstance that many coal-seams are impregnated with salts, and are associated with beds containing marine fossils.

5. "Note on some Dinosaurian Remains in the Collection of A. Leeds, Esq. Part I. *Ornithopsis Leedsii*. Part II. *Omosaurus*, sp." By J. W. Hulke, Esq., F.R.S., F.G.S.

Part I. *Ornithopsis Leedsii*, nov. sp., from the Kimmeridge Clay of Northamptonshire.

The author described a pelvis, vertebræ and costæ referable to this genus, of a stature far surpassing that represented by the pelvis in the Fox Collection from the Isle of Wight Wealden, which he brought under the notice of the Society a few years since. The ilium has a very long preacetabular process. A rib is three times as large as the largest rib of an elephant of average stature. The trunk vertebræ show the characteristic large chamber opening in the side of the centrum, under the platform supporting the neurapophyses. There is no post-pubis. The pubis and ischium diverge; their close resemblance to those of *Cetiosaurus oxoniensis*, figured by J. Phillips, in the 'Geology of Oxford,' is obvious when each figure

is reversed, their true position being misrepresented in that author's diagram, a very excusable error.

Part II. described a sacrum, with ilia, vertebræ, a femur, etc. The neural arches of the sacral vertebræ are synostosed, and so form a continuous roof (simulating the vault of a cranium) of the dilatation of the neural canal, which enclosed the sacral swelling of the spinal cord. The transverse processes are long. The ilia offer a general resemblance to those of *Osmosaurus armatus* (Owen), but differ from those of this species in the relatively greater length and narrowness of the preacetabular process. The similarity of construction of this sacrum to that of *Stegosaurus*, described by O. C. Marsh, and the very close resemblance of their ilia were noticed. The author considered that an extremely close affinity exists between these two genera, and is prepared to find that, upon the acquisition of more materials, their identity may even be established. For the present, he preferred to refer the Peterborough Dinosaur to *Omosaurus*, and proposed for its specific name *durobrivensis*, having reference to that of the old Roman settlement in that locality.

6. "Notes on some Polyzoa from the Lias." By Edwin A. Walford, Esq., F.G.S.

The author briefly reviewed the work of Etheridge, Vine, and others in the tabulating of the British Liassic Polyzoa, and mentioned also the labours of Terquem and Piette, Dumortier, and others in the same direction in France and Germany. He directed attention to a species described by Prof. Tate from the Lias of May, Normandy, under the name *Spiropora liassica*, and described specimens in his own collection from a similar horizon in the Midlands, with which it had been confounded. The English forms have very varying modes of growth; sometimes foliaceous after the fashion of the *Diastopora* proper of Haime, at other times ramose and cylindrical, like *Entalophora*. The latter habit, together with the long, and often partly free, zoœcia, suggest the relationship of the species with the *Tubuliporæ*. The exceptional state of preservation of the specimen is such as to show the cells in a perfect condition, with solid circular calcareous closures within the orifice of the zoœcial tubes, a feature common to both the foliaceous and the cylindrical forms. The surface-pores are unusually well preserved, and appear to be similar to those of the recent Cyclostomatous Polyzoa. The name of *Tubulipora inconstans* is proposed for the species.

Mention was also made of other fragments of Polyzoa of doubtful relationship occurring in the same beds.

7. "On the Superficial Geology of the Southern Portion of the Wealden Area." By J. Vincent Elsden, Esq., B.Sc. Communicated by the President.

The author, after referring to Sir R. Murchison's paper, published more than thirty years ago, on "The Distribution of the Flint Drift of the S.E. of England," proceeded to give in detail his observations on the angular flint-deposits of the Arun, Adur, Ouse, and Cuckmere basins, He also noticed a sandy or loamy deposit containing angular fragments of ironstone, and generally a few small angular flints that

occurred on the surface of the Lower Greensand, and to a small extent on the Weald Clay. A block of granite, weighing between 5 and 6 lbs., was found on the chalk escarpment at Kilhurst Hill.

The angular flint-drift occurred mainly on the higher parts of the area, and was wanting in the river-valleys, where, however, river-gravels derived from the denudation of the older deposits were abundantly developed. This distribution of the angular drift was shown to be incompatible with the theory of its origin advocated by Sir R. Murchison and some other geologists, who attributed it to a violent and transitory current. The author showed that not only in the Wealden area, but throughout many of the neighbouring districts, the angular drift consisted of the undenuded remnants of a deposit formed before the present river-valleys were cut, and that many of the river-gravels, though newer than the angular drift, were deposited when the valleys had been less excavated than they now are. This was Mr. Topley's view with respect to the northern portion of the Wealden area. Mr. Searles V. Wood's marine theory of the origin of these gravels was discussed, and shown to be refuted by their mode of occurrence. It was, moreover, contended that the drift, although composed of local materials, was probably of sub-aqueous origin, and not merely subaerial. The discovery of a granite boulder might, if confirmed by other discoveries, lead to a modification of the views generally held as to the physical character of the area during the Glacial period.

8. "Report on Palæo-botanical Investigations of the Tertiary Flora of Australia." By. Dr. Constantin Baron von Ettingshausen, For.Corr.G.S. (This paper appears in full in this MAGAZINE.)

9. "On some new Features in *Pelanechinus corallinus*." By T. T. Groom, Esq. Communicated by Prof. T. M'Kenny Hughes, M.A., F.G.S.

The discovery by the author, in the Coral Rag at Calne, of an additional and well-preserved specimen of the Echinoderm originally described by Dr. Wright as a *Hemipedina*, but subsequently made the type of a new genus, *Pelanechinus*, by Mr. Walter Keeping, afforded an opportunity of adding considerably to the known characters of the type. The test proved to be flexible, as in the Echinothuridæ, a point already noted by Mr. Keeping.

A number of details as to the interambulacral and ambulacral areas, the imbricating peristomial plates, pedicellariæ, and teeth were given. Pedicellariæ did not appear to have been previously observed in fossils.

The genus appeared to occupy an intermediate position between the Echinothuridæ, Echinidæ, and Diadematidæ, and must form the type of a distinct subfamily, perhaps referable to the last named. A new description of the species was added.

10. "On Boulders found in Seams of Coal." By John Spencer, Esq., F.G.S.

The discovery of a boulder weighing 6 lbs., and composed of

granite, in the Gannister or Mountain-Mine seam of the Rossendale district, at Old Meadows Pit, near Bacup, Lancashire, had led the author to call attention to the occasional occurrence of similar boulders in various parts of Lancashire and Yorkshire. Such boulders were always isolated, and sometimes imbedded in the seam, sometimes in its upper surface. They were always waterworn and rounded, and were composed, so far as had been observed, of granite, gneiss or quartzite foreign to the district.

After considering the various suggestions that had been made as to the means by which such boulders had found their way into the coal, the author gave the preference to the action of floating-ice, both because the presence of fragments from a distance would thus be more readily explained, and because ice-scratched rocks have been found *in situ* in the Millstone Grit within three miles of the place whence the boulder mentioned was obtained.

The next Meeting of the Society will be held on Wednesday, 9th November.

III.—Zoological Society of London.

May 17th, 1887.—Prof. W. H. Flower, LL.D., F.R.S., President, in the Chair.—The following communications were read :—

1. "On the Presence of a Canal System, evidently Sensory, in the Shields of Pteraspidian Fishes." By A. Smith Woodward, F.Z.S.

A broken specimen of *Pteraspis Crouchii* in the British Museum adds an interesting fact to our knowledge of the structure of the shield in the Pteraspidian fishes. In his well-known monograph on this ancient group, Prof. Ray Lankester described a number of pits or depressions arranged in rows upon the external surface of certain well-preserved examples, and considered that they were connected with the "lateral line" system of the fish, probably lodging the sensory organs situated in an enveloping soft integument. The same feature was again described in *Holaspis* in 1873 (Geol. Mag. Vol. X. p. 243, Pl. X.) It now appears that these curious depressions are really the openings of a canal system, traversing the middle layer of the shield, and quite comparable to the canals of the lateral line in many ganoids and teleosteans. The branches have the remarkable "feather-barb" arrangement, so well seen in the living Pleuronectidæ.

2. "Note on the 'Lateral Line' of *Squaloraja*." By A. Smith Woodward, F.Z.S.

In his description of the genus *Squaloraja*, recently published, the author had failed to recognise traces of the lateral line. He now showed that these canals were supported by numerous minute, incomplete, calcified rings, exactly similar to those well known in recent and fossil Chimæroids. The fact probably implied that the sensory organs were placed in open grooves, and thus added one more feature to those already noted as connecting the old Liassic Selachian with the Holocephala.

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2. June 23rd, 1887.—Prof. W. H. Flower, LL.D., F.R.S., President, in the chair.—The following communications were read:—

1. "Note on a Fossil Species of *Chlamydoselachus*." By James W. Davis, F.G.S.

The author showed that some teeth described and figured about ten years ago by R. Lawley ("Nuovi Studi sopra ai Pesci, etc.," Florence, 1876, p. 87, pl. i. figs. 1, *a-c*) were truly referable to the newly-discovered Japanese Shark, *Chlamydoselachus*, Garman. These fossils were obtained from the Pliocene of Orciano, Tuscany, and their original discoverer was naturally perplexed in determining their relationships; he left them *incertæ sedis*, and refrained from proposing a name. Mr. Davis suggested that the new species be known as *C. Lawleyi*.

2. "On the Fossil Teleostean Genus *Rhacolepis*, Agassiz." By A. Smith Woodward, F.Z.S.

This communication contained a detailed description of the Brazilian fossil fish briefly noticed by Agassiz under the name of *Rhacolepis*, and concluded by discussing the systematic position of the genus. The original determination was founded upon a collection of fossils obtained by Mr. G. Gardner, about 1840, from Barra do Jardim, Serra de Araripe, North Brazil, and brief notes were published in the "Edinb. New Phil. Journ." 1841, and the "Comptes Rendus," vol. xviii. p. 1007. An early figure, without name, was also given in the Atlas accompanying Spix and Martius' "Reise in Brasilien," 1823. A large number of specimens now in the British Museum display the principal characters of the skeleton, and also show well-preserved traces of the gills and the lateral muscles of the trunk. The body exhibits but slight lateral compression, and the abdomen is rounded; the snout is acutely pointed, and the roof of the skull flattened. The margin of the upper jaw is formed both by the premaxillæ and maxillæ, and the cleft of the mouth is nearly horizontal; the cheek is covered by the expanded posterior circumorbital bones; there is a narrow preoperculum, a triangular interoperculum, and a relatively large suboperculum. The branchiostegal rays are numerous, about ten, of considerable size, being attached to the epihyal, and an equal number of smaller ones to the ceratohyal. There is a single dorsal fin in the middle of the back; the pelvic fins are abdominal in position, opposite the dorsal, and each consists of about 12 soft rays; the anal is situated half-way between the pelvics and the caudal; and the latter is deeply forked. The scales are cycloid and beautifully marked with delicate radiating rugæ; thin scales also appear upon portions of the dorsal and caudal fins. A distinct "axillary appendage" is observable above the pectoral fin. Three species can be distinguished, and are separated by the form of the body, and the proportions of the operculum and posterior circumorbital bones; they were respectively named by Agassiz, *R. brama*, *R. buccalis*, and *R. latus*, and many of the National fossils bear his MS. labels. The newly-determined characters show that *Rhacolepis* is not a Percoid or Berycoid, as originally supposed, but a truly Physostomous fish. The author concluded that it was an Elopine Clupeoid.

CORRESPONDENCE.

NOTES ON CHELONIA.

Sir,—In the interesting "Notes on Chelonia from the Purbeck, Wealden, and London-clay," by Messrs. Lydekker and Boulenger, in the May Number of this Magazine, the authors refer to the generic identity of the plastron named by Prof. Sir R. Owen *Platemys Bullockii*, supposed to have been obtained from the London-clay at Sheppey, and the plastra of the same author's genus *Pleurosternon* from the Purbecks. In regard to which will you allow me to state, that when arranging the fossil Chelonia, some fourteen or fifteen years ago, in the Museum cases at Bloomsbury, I observed that the structural characters of the plastra of *Platemys Bullockii* and of *Pleurosternon* were the same, and that the two genera must be merged into one. This conclusion was further confirmed by a closer examination of the matrix adherent to the former, which proved it to have been derived from the Purbecks, and not as stated from the London clay. The specimen has ever since been exhibited in the Museum cases with the following label attached, "*Pleurosternon* (*Platemys*) *Bullockii*, Owen, Purbeck beds, Swanage."

Though the locality is not positively known, there can be little doubt that the specimen was found in the "Isle" of Purbeck, and in the neighbourhood of Swanage. Prof. Rütimeyer's remarks upon the same subject were, I am sorry to admit, unknown to me until very recently.

Wm. Davies.

THE LIZARD SERPENTINES.

Sir,—It appeared to me that, in regard to the existence of felspar in the Rill serpentine,[1] lately in dispute between Mr. Teall and myself, the evidence of a chemical analysis of the rock would do much to clear up the question. Through the kindness of Dr. S. Rideal, a partial analysis of this serpentine has been made in the Chemical Laboratory at University College with the following results in two cases:—

	I.	II.
SiO_2	42·70	42·63
Al_2O_3	14·79	14·05
Fe_2O_3	8·77	8·55
CaO	3·05	3·22
MgO	17·08	18·68
	86·39	87·13

The water, alkalies, etc., were not estimated, as I had said that probably the silica, alumina, and magnesia would suffice for my purpose. At first sight this analysis appears conclusive in favour of Mr. Teall's contention, that there is felspar in the rock. It is the analysis of a picrite, so far as such a variable rock can be said to have a typical analysis. Indeed, the proportion of alumina is large even for a picrite. But I still feel perplexed, for on consideration of the analysis it appears to me to "prove too much." Suppose the alumina all present in the felspar, and that to be anorthite; for

[1] See Geol. Mag. Feb. 1887, p. 69, and March, 1887, p. 137.

rough calculations take the alumina as 14 per cent., and use the proportions given by Nicol in his Mineralogy: then there will be in anorthite $\frac{43}{37} \times 14$ of silica, and $\frac{20}{37} \times 14$ of lime, i. e. the amounts of silica and of lime in the felspar will be nearly 16·3 and 7·6 respectively. But the amount of CaO in the analyses is only 3·05 or 3·22. Moreover, the total of the constituents in the anorthite would be nearly 37; or more than a third of the rock would be felspar, which is certainly far too much for any slide that I have seen. If the amount be calculated from the lime, 5·5 of the alumina would be needed, and 6·5 of the silica, and the felspar would be 26 per cent. of the rock,—still too much, and there would be 8·5 of the alumina left. In both these cases also there is not magnesia enough for the remaining silica, if, as seems certain, another principal constituent has been olivine. Suppose, however, the felspar be labradorite; then, calculating in the same way, and supposing all the lime to be a constituent of that mineral, we require 8 per cent. of the alumina, leaving 6 per cent., so that the rock should be rather rich in such a mineral as spinel, which it is not. In this case also the proportionate amount of felspar seems considerably in excess of the amount of the mineral which has been claimed. I have made various other trial calculations from the analysis, and in no case can I obtain results which seem to accord with the microscopic structure of the rock, even in matters on which I believe we should be in agreement.

I may indeed add that I have more than once found a similar apparent discrepancy between the microscopic and the chemical analysis of a picrite, and had reason to suspect that the alumina was mainly present as the constituent of a mineral other than felspar. So, notwithstanding the apparently conclusive evidence of the chemical analysis, on which I frankly admit Mr. Teall is entitled to claim a verdict in his favour, I still feel very strongly the difficulties as to the identification of the mineral alleged in my former communication, and am not sure that the question is even yet decided beyond all appeal.

T. G. Bonney.

THE BAGSHOT SANDS.

Sir,—I do not think Mr. R. S. Herries (Geol. Mag. April, 1887, p. 192) has found such a 'mare's nest' as he seems to imagine. The note he has quoted from vol. iv. of the Memoirs of the Geological Survey, of a pebble-bed somewhere near Barkham, has long been familiar to me; but I have never succeeded in finding *the* pit to which the description would apply. Short of the identification of the pit, which I have described in my paper in the Geol. Mag. for March last, by the original writer of the note quoted, I cannot admit its application to the case in question. If the author of that note is prepared to vouch for the supposed identification, the inaccuracy of the description will go far to vitiate the evidence of similar notes from the same source. I leave my critics to choose between the horns of this dilemma.

In speaking of an "unmappped outlier," it was simply intended to imply that the beds under consideration *had not been mapped out*

as an outlier. A portion of them had been mapped, as I knew perfectly well; but, as I think, wrongly. As a matter of fact, they are found to extend half a mile further to the north, than the boundary-line drawn on the map. When Mr. Herries shall have made as complete and close an examination of the locality as I have made, I shall be glad to welcome further criticisms from him on my paper; meanwhile I do not feel quite justified in filling up the pages of the GEOLOGICAL MAGAZINE in recording "glimpses of the obvious."

A. IRVING.

WELLINGTON COLLEGE, BERKS.

OBITUARY.

ARTHUR CHAMPERNOWNE, M.A., J.P., F.G.S.

BORN MARCH 19TH, 1839; DIED MAY 22ND,[1] 1887.

EVER and anon as we press forward in life's journey we are confronted with the loss of some valued friend and comrade, in whose removal we seem to suffer a far greater hardship than any other we have had to bear. To many of us such a feeling arises when we recall the keen sorrow of a few weeks since at the loss of our fellow-worker in geology, Arthur Champernowne.

He was the eldest son of Henry Champernowne, Esq., of Dartington Hall, Totnes, South Devon, and belonged to one of the oldest families in Devonshire. His father died in 1851, whilst Arthur was only 12 years of age. He was educated at Eton, whence he passed to Trinity College, Oxford, where he graduated as M.A. In 1870 he married Helen, daughter of M. L. Melville, Esq., of Hartfield Grove, Sussex.

Soon after he settled down in Devonshire, he became acquainted with William Pengelly, F.R.S., of Lamorna, and John Edward Lee, F.G.S., of Villa Syracusa, Torquay, the latter of whom was the intimate friend of Prof. John Phillips, of Oxford, whose lectures Arthur Champernowne had attended. The interest these geologists aroused in his mind caused him to look around his own county and try to understand, and finally to map, probably one of the most complex pieces of country in the whole of England.

Mr. Champernowne never enjoyed robust health, but his earnestness and enthusiasm in whatever he undertook carried him through successfully. He was an excellent artist, and when travelling for his health in Italy, he made many sketches; but after he took up geology he only used his pencil to prepare sections and draw fossils, which he executed with great skill and fidelity.

He geologised in Spain, and in order the better to comprehend his native county, he made repeated expeditions to the Devonian rocks of the Eifel, on one occasion with Mr. John Edward Lee, of Torquay,

[1] The 5th June was by an error the date quoted in the July Number GEOL. MAG.—EDIT.

spending some time at Prüm and Gerolstein. He also geologised at Paffrath and in other parts of Germany and Belgium. His last foreign trip to Belgium was particularly interesting to him, and he was enabled to confirm many of his views as to the geology of South Devon by what he saw in the Meuse Valley. In this visit he was greatly assisted by M. Dupont, the Director of the Geological Survey, who desired M. Alphonse Le Duc to accompany Mr. Champernowne over much of the ground he wished to see and study.

He took the greatest interest in the Devonian Corals, in the working out of which he never seemed to tire. He was the first who discovered the *Calceola* Limestone, and obtained specimens from the cliff-section immediately below Daddy-hole-plain, Torquay—in front of Mr. Lee's house. He also obtained the fine *Homalonotus* from the Devonian of the "New Cut," Torquay (figured in the Geol. Mag. 1881, Pl. XIII. p. 489), and named after him by the writer. So keen was he in the field that wherever he geologised he invariably was the first to discover fossils, and usually the best specimens fell to his own hammer.

During his Devonian researches he discovered in the "Pit-Park Quarry" near the Hall, a vast number of Stromatoporoids, which led him to enter into an earnest correspondence and have frequent interesting conversations with Dr. H. J. Carter, F.R.S., of Budleigh Salterton, Devon, who had taken much interest in this group of organisms. Mr. Champernowne with great diligence extracted large numbers of these fossils from the Limestone, and had numerous sections cut and polished at his own cost to illustrate their internal structure, and he most liberally distributed these to various museums and individuals interested in their examination.

Prof. Nicholson writes, "Mr. Champernowne took a special interest in the Stromatoporoids, and gave me throughout the most unselfish and ungrudging help in the work I had undertaken, namely, to prepare a Monograph on this group of organisms for the Palæontographical Society. He not only placed at my disposal the whole of his splendid collection from the British Devonians, but he freely laid before me the results of his own studies in these difficult fossils; indeed, I owe more than I could easily measure to his friendly criticisms on my work, and his wise suggestions as to the particular lines of research which it would be wise for me to follow. With this feeling, I cannot but recognize in the death of Arthur Champernowne that a heavy loss has befallen the small band of British Palæontologists of which he was so excellent a type. It is not only a gifted scientific observer that has gone from amongst us, but a genuine man and a loyal and true-hearted friend."

With Mr. Horace B. Woodward, Mr. W. A. E. Ussher, of the Geological Survey, and Mr. Frank Rutley, he was in frequent correspondence; and when the former Surveyors were at work in his area, it afforded Mr. Champernowne the keenest pleasure to join them in the field and share his knowledge of the country with them.

The visit paid to Devonshire by Prof. Dr. Ferdinand Roemer, of Breslau (the Geological Historian of the Devonian rocks of the

Eifel) afforded Mr. Champernowne the utmost gratification, as confirming the views which he had arrived at, together with Mr. John Edward Lee, on the Upper Devonian Goniatite Limestone in Devonshire (see GEOL. MAG. 1880, Pl. V. p. 145) and other kindred subjects.

Mr. Champernowne was at the time of his death a Member of the Councils of the Geological and of the Palæontographical Societies, in both of which he took the warmest interest. He was a frequent contributor to the Quarterly Journal of the former Society as well as to the GEOLOGICAL MAGAZINE.

Mr. Horace B. Woodward frequently refers to Mr. Champernowne, and acknowledges his great indebtedness to him for revising the Devonian chapters of his "Geology of England and Wales" (2nd edition just published).

The Director-General of the Geological Survey, Prof. Geikie, told the writer, "When I saw Mr. Arthur Champernowne's detailed geological colouring on the Ordnance Maps of his own area, I was delighted with the beauty and clearness of the work, and after going over the ground with him, I was equally convinced of its careful accuracy.

"When I proposed to him that he should allow me to incorporate his work on the Survey Sheets, he was greatly pleased, but so modest and diffident was he, that after spending years on this area, he expressed his anxiety to go over it all again before allowing me to accept it as quite complete."

It was after attending the Council Meeting of the Geological Society on May 11th, that he hurried down to Dartington intent on setting to work at once upon a revision of his maps, and having gone abroad in unfavourable weather, and suffering from a severe cold, he caught a chill which developed into inflammation of the lungs, under which he gradually sunk.

Mr. Champernowne was connected with every work of benevolence and public usefulness in his own district. As a Magistrate he was most conscientious in the discharge of his duties; as a Landlord he was most generous, and lived upon the best terms with all his tenantry, his constant aim being to promote their welfare. His death was felt as a common sorrow, and his funeral was attended by representatives of all ranks of society each of whom seemed to feel that in the deceased he had lost a personal friend.

Mr. Champernowne leaves a widow and ten children, the eldest, a boy of only fifteen years, to deplore his early loss.

> Like shadowy watchers by some misty shore,
> We stretch our arms towards the silent main,
> And sigh for those we ne'er shall look on more,
> Whose hand-clasp we may never feel again.

There is no fear that the name of ARTHUR CHAMPERNOWNE will be soon forgotten, either in his home-circle, or in that wider scientific circle of friends, to be associated with whom as a fellow-worker he always esteemed to be his greatest happiness.—H.W.